



HAL
open science

A Concise Review on Natural Fibers and Their Surface Modification for Fabricating Natural Fiber Reinforced Polymer Based Composites

Mohammad Bellal Hoque, Md Mostafizur Rahman, Nadia Shabnaz Lupa

► **To cite this version:**

Mohammad Bellal Hoque, Md Mostafizur Rahman, Nadia Shabnaz Lupa. A Concise Review on Natural Fibers and Their Surface Modification for Fabricating Natural Fiber Reinforced Polymer Based Composites. Journal of Fareast International University, 2022, 5 (1), pp.23-31. hal-04553976

HAL Id: hal-04553976

<https://hal.science/hal-04553976v1>

Submitted on 24 Apr 2024

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.



Distributed under a Creative Commons Attribution - NonCommercial 4.0 International License

A Concise Review on Natural Fibers and Their Surface Modification for Fabricating Natural Fiber Reinforced Polymer Based Composites

Mohammad Bellal Hoque¹, Md. Mostafizur Rahman², Nadia Shabnaz Lupa³

Keywords: Natural Fiber, Composite, Surface Modification, Mechanical Properties, Polymer

Journal of Fareast International University [ISSN 2519-9951]

Volume 5, Issue 1, 2022 [Pages 23-31]

In recent years, natural fiber reinforced composites have drawn much attention due to its cheap cost, biodegradable, flammable, nontoxic, and nonabrasive qualities. Natural fibers such as flax, bamboo, sisal, hemp, ramie, jute, and wood are especially captivating among the several types of natural fibers. Natural fibers have been extensively studied worldwide for their potential use as reinforcing materials in the production of diverse composite materials. The quality of the fiber-matrix interface is one of the most crucial variables that determines the ultimate performance of the composite materials. Natural fibers can be pretreated to improve surface roughness, chemically alter the surface, clean the fiber and halt the process of absorbing moisture. Among the various pretreatment techniques alkali treatment is one of the most affordable and cautious chemical techniques for the surface modification of natural fibers. Better mechanical interlocking is produced by alkaline treatment because it enhances surface roughness and removes the cellulosic substance that covers the external surface of the fiber cell wall. This article provides a review on the use of pretreated natural fibers in polymer matrix-based composites. The effect of surface modification on the mechanical properties of natural fiber reinforced polymer based composites has also been discussed in this review study.

INTRODUCTION

The use of natural fiber from plants as fortified element of composite materials is not a new notion. It has been used fruitfully by several nation of the world from many ago. The deal of natural fiber in composite materials is to enhance the stiffness, strength and impact resistance of the whole material. Several natural fibers have been served this purpose very well as seen in the history. However, it has been noticed for last few decades that the interest of using natural fiber as reinforcing element in fiber polymer composite materials has been increased to a great extent (Ludueña et al., 2012).

Natural fiber reinforced composite materials are related to the economics of rural people as they can earn from cultivating natural fiber even from selling the agro wastage. So the national economy can be benefited in this way. Reducing the dependency on petroleum based materials is another important factor concerned with the natural fibrous composites. Moreover the whole world is much aware about the pollution, energy and waste of raw materials. Governments and private interest group have been imposing several rules and laws regarding these issues. Natural fiber reinforced polymer based composites could be a source to reduce pollution and save energy and waste of raw materials as a replacement

¹Senior Lecturer, Department of Textile Engineering, World University of Bangladesh, Dhaka, Bangladesh [bellal.hoque@textiles.wub.edu.bd]

²Assistant Professor & Head, Department of Textile Engineering, World University of Bangladesh, Dhaka, Bangladesh [rahman6@textiles.wub.edu.bd]

³Student, Department of Textile Engineering, Fareast International University, Dhaka, Bangladesh [nadiashabnaz7899@gmail.com]

of tradition composite, metal and wood structure (John, 2008 ; Ng et al., 2020).

The applications of natural fibrous composites have been growing day by day. Fabricating composites with natural fiber is more challenging rather than engineered fiber. The dissimilarities of natural fiber with engineered fiber arise due to the constitution of natural fiber, species, fabric specification or manufacturing technique. That's why these matters need to be taken into account before developing composite with natural fiber (Zhang et al., 2011).

Some specific properties need to be figured out by the researcher while liken the natural fibrous composites with engineered fibrous composites such as glass or carbon fiber as reinforcing element in composite materials. Geometrically the natural fibers have irregular cross sectional area along with they are not uniform cylindrical shape as engineered fibers. The natural fibers are available as bundle form that have the problem of void area (Doherty et al., 2011; Musa et al., 2020). Chemically, the surface energy of natural fibers differ and for having diverse natural polymer the main bonding sites of natural fibers are formed along with the fiber length that generate these elementary bundle. These dissimilarities of natural fibers with engineered fibers should be optimized before replacing natural fiber in place of engineered fiber. That's why the modern innovation including the modification of natural fiber is required and several attempts have been noticed in this regard to step ahead the natural fiber reinforced composites technology (Fiore et al., 2020; Zhao et al., 2019).

Some other undesirable factors such as plant varieties and their growing criteria, uncertain demand, dependency on weather condition etc. are also related with natural fibers which act as a barrier to widespread development of bio composites. But the most promising aspects of natural fibrous composites include low thermal degradability and utilization of surface characteristics to improve the adhesion with polymer matrix for better load transfer and protection from moisture and decay (Summerscales et al., 2010).

MATERIALS AND METHODS

Materials

A variety of synthetic (E-glass, polyester, carbon, alginate, etc.) and natural (Jute, flax, kenaf, ramie, pineapple leaf fiber, etc.) fibers can be utilized as reinforced elements in composite materials. Several research studies have used polypropylene (PP), polyethylene (PE), unsaturated polyester resin (UPR), and epoxy resin as matrix materials.

Methods of Composite Fabrication

Fiber reinforced composite materials can be made using a variety of techniques, including spray up, injection molding, pultrusion, compression molding, and hand lay-up. They are described below:

Compression Molding: The most common method of making composites is compression molding. This method uses high temperatures and pressures. Depending on the kind of matrix material, temperatures ranging from 110 to 200°C are used as an attempt to melt it. The ideal operating temperature lies between the melting point of the reinforcing components and the melting temperature of the matrix materials. Pressures ranging from one to five tons are applied to the composite materials in conjunction with high temperatures to give the composite the correct shape. The reinforcing materials must be guaranteed to be unaffected by pressure and temperature. Before applying high pressure and temperature, two steel plates are usually wrapped in silicon paper and used outside the composite.

Hand Lay-up: The simplest and oldest way of fabricating composites is manual lay-up. This technique involves evenly dispersing fiber onto a mold and then scattering the resin matrix over the fiber. After that, a hand roller is used to roll it out evenly throughout the resin matrix. Additionally, hand rolling helps to achieve the necessary thickness and guarantees improved contact between the reinforcement and matrix.

Pultrusion: The automated method of pultrusion is used to create composite materials with a continuous, consistent cross-sectional profile. The products are removed from the dice rather than being compressed out. Pultrusion is a method used to make several sorts of structures, including rods and tubes.

Injection Molding: For the large-scale production of composite materials, the injection molding method is employed. With this technique, thermoset and thermoplastic composites can be produced. The composites are combined, poured into a mold cavity, cooled, and allowed to harden into the required shape inside a heated barrel.

Spray-up: Composite is formed quickly and uniformly using the spray-up process. The hand lay-up and spray-up techniques are somewhat comparable. One potential downside of the spray up approach is that it yields moderate mechanical

characteristics. Its inability to use continuous fiber for reinforcing is another drawback. A separate sprayer is used to apply liquid resin and chopped fiber, resulting in the formation of composite.

Mechanical properties

The tensile characteristics (tensile strength, elongation at break, and tensile modulus) of composites with varying cross-head speeds are determined using the Universal Testing Machine (UTM). Tensile specimens are typically prepared using ASTM-D638-01. The following formula can be used to compute tensile strength-

$$\text{Tensile Strength} = \frac{\text{Applied Force}}{\text{Cross Sectional Area}}$$

The value may be expressed in Nm², MPa, or GPa. The percentage basis of tensile strain is used to express elongation at break. It is also possible to calculate tensile strain using ASTM-D638-01. Tensile strain of composites is defined as the variation of final length from their starting length based on that beginning length. By using universal testing equipment, the ratio of stress to strain can be used to determine the young modulus. The machine that is described for the tensile properties can also be used to determine the bending properties, such as the bending modulus and its strength. (Hoque et al., 2021).

NATURAL FIBERS AND THEIR COMPOSITE

The fibers which are obtained from animals or plants are referred to as natural fiber. It is also termed as vegetable fiber. The use of natural fiber as substitute of fortified element of composite materials have been noticed widely. The conventional lingo cellulosic engineered fiber such as glass or carbon fiber are familiar with several benefits to the composites such as rigid, flexible, lower in density, cost effective etc. The fibers which are obtained from natural source like jute, cotton, bamboo, coir and sisal are rich in the percentage of cellulose in their raw form. The most interesting thing is the byproducts which we deem as wastage have also a good percentage of cellulosic content like pineapple leaf fiber, wood pulp, wood flour, shell flour and they are suitable to use as reinforcing element of composite materials. The types of natural fibers, their sources and the percentage of cellulose content are grouped together in table 1 to get an idea (Tongnunui, 2014) –

Table 1: Natural fibers, their sources and cellulose content

| Natural fiber | Source | Cellulose content (%) |
|---------------|--------|-----------------------|
| Cotton | Seed | 82.7-92 |
| Jute | Stem | 61-73.2 |
| Flax | Stem | 71-81 |
| Hemp | Stem | 70.2-74.4 |
| Coir | Fruit | 32-47 |
| Banana | Stem | 63-67.6 |
| Bamboo | Stem | 48.2-60.8 |
| Pineapple | Leaf | 70-82 |
| Kenaf | Stem | 28-39 |
| Ramie | Stem | 68.6-76.2 |
| Sisal | Leaf | 56.5-78 |
| Bagasse | Stem | 55.2 |
| Okra | Stem | 46.6-49.3 |

There are different types of method are available for fabricating composites such as compression moulding, hand lay-up, pultrusion, injection moulding, spray-up, etc. The following table (Table 4) is revealing different technique of composites based on several studies.

Natural fiber reinforced composite materials are also termed as “Green Composites”. Now a days natural fiber composites are a good source of earning currency that inspires and widespread the use of natural fiber. It is also promoted to develop eco-friendly materials that have industrial applications as a substitute of reprehensible materials to environment. Researchers and scientists are paying their heed to figure out every possible scope to discover such materials. The use of different sort of natural fibers such as jute, ramie, sisal, flax etc. along with their blending from non-renewable and renewable sources have been noticed in this attempt to fabricate fiber polymer composite materials. These composite materials have become a wonderful material due to its widespread implementation in the field of aviation, automobile, arm forces, railway, building materials and packaging (Mohanty & Misra, 2012).

Thakur narrated that natural fibers had the dominating use as the raw material of structural and architectural components thousands of years ago (Thakur, 2013). Natural fiber reinforced composite materials were step ahead from the essence of environmental issues and for the smooth living of biotic existence.

For being stiffer, light weight and low cost, the plant fibers could be a fruitful substitute of man-made or synthetic fiber reinforced polymer composites as mentioned by Singha and Thakur (2009). Murugan & Jeyaraj (2017) conducted a research on traditional natural yarn fabric composites and braided yarn fabric composites. They have found better mechanical

properties in case of natural fiber based braided yarn reinforced composites. They also reported a very high

impact strength of conventional natural yarn fabric composites in parallel to braided yarn composites.

Table 2: Chemical compositions of different natural fibers at a glance (Sathishkumar et al., 2013)

| Fiber Name | Cellulose (%) | Lignin (%) | Hemi Cellulose (%) | Pectin (%) | Wax (%) | Moisture (%) | Ash (%) | Micro fibrillar Angle ($^{\circ}$) |
|------------|---------------|------------|--------------------|------------|---------|--------------|-----------|--------------------------------------|
| Cotton | 82.7–90 | – | 3 | – | 0.6 | 7.85–8.5 | – | – |
| Pineapple | 70–82 | 5–12.7 | – | 1.1 | 3–3.3 | 11.8 | 0.71–0.87 | 14 |
| Kenaf | 45–57 | 21.5 | 8–13 | 0.6 | 0.8 | 6.2–12 | 2–5 | 2–6.2 |
| Jute | 61–71.5 | 11.8–13 | 17.9–22.4 | 0.2 | 0.5 | 12.5–13.7 | 0.5–2 | 8 |
| Hemp | 70.2–74.4 | 3.7–5.7 | 17.9–22.4 | 0.9 | 0.8 | 6.2–12 | 0.8 | 2–6.2 |
| Sisal | 78 | 8 | 10 | – | 2 | 11 | 1 | 20–25 |
| Flax | 64.1–71.9 | 2.0–2.2 | 64.1–71.9 | 1.8–2.3 | 1.7 | 8–12 | – | 5–10 |

Table 3: Mechanical properties of natural fibers (Sathishkumar et al., 2013)

| Sl. No. | Fiber Name | Tensile Strength (MPa) | Tensile Modulus (GPa) | Elongation at Break (%) |
|---------|------------|------------------------|-----------------------|-------------------------|
| 01. | Pineapple | 413–1627 | 34.5–82.5 | 0.8–1.6 |
| 02. | Cotton | 400 | 5.5–12.6 | 7.0–8.0 |
| 03. | Hemp | 550–900 | 70 | 2–4 |
| 04. | Jute | 393–773 | 10–30 | 1.5–1.8 |
| 05. | Flax | 345–1500 | 27.6–80 | 0.2–3.2 |
| 06. | Ramie | 220–938 | 44–128 | 2–3.8 |
| 07. | Bamboo | 503 | 35.91 | 1.40 |
| 08. | Coir | 500 | 2.5 | 20 |

Ramesh et al. (2013) proposed blended jute and sisal fiber reinforced polymer based composites as a substitute of glass fiber reinforced composites. They observed improved mechanical properties (tensile, bending and impact strength) in case of blended jute and sisal fiber reinforced polymer based composite materials. Scanning electron microscope was also applied on prepared composites to evaluate the interfacial properties such as bonding, crack and structure.

Table 4: Different technique for fabricating composites

| Sl. No. | Name of the composite | Fabrication Technique | Reference |
|---------|--|-----------------------|--------------------------------|
| 01. | PALF-Kenaf hybrid fiber/PP | Compression Molding | (Ng et al., 2020) |
| 02. | PALF/Nylon | Injection Molding | (Nopparut & Amornsakcha, 2016) |
| 03. | PALF-Jute-Glass hybrid fiber/Epoxy resin | Hand Lay-up | (Ramaiah et al., 2011) |

After comparing the overall properties of blended jute and sisal fiber reinforced polymer composites with glass fiber reinforced composites, they suggested jute and sisal fiber reinforced composites could be an alternative of glass fiber reinforced composite materials.

Thakur & Singha (2010) analyzed on the synthesis and characterization of Grewiaoptiva fiber reinforced Phenol-Formaldehyde composites. They observed increased mechanical properties of pure resin due to incorporation of Grewiaoptiva fiber. They also analyzed the surface and thermal properties of prepared composites. They mentioned Grewiaoptiva fiber reinforced Phenol-Formaldehyde composites as a potential composite material along with various implementations.

Singha and Thakur (2010) fabricated pineapple fiber reinforced polymer based composites to check out the thermal and mechanical behavior. The composites were prepared by using compression moulding technique. They used short pineapple leaf fiber (length 3 mm) to fabricate composites. The weight percentage of pineapple leaf fiber in fabricated composites was varied from 10% to 30%. Their results revealed upmost values of mechanical properties at 30 wt% fiber composites. Scanning electron microscopy was also applied to figure the morphological properties.

Vimalanathan et al. (2016) fabricated Shorea Robusta fiber reinforced unsaturated polyester resin based composites. The composites were fabricated by using simple hand lay-up technique. They used short fiber ranges from 2 to 25 volume fraction to fabricate the composites. Thermal, mechanical and biodegradability of Shorea Robusta fiber reinforced unsaturated polyester resin based composites were experimented in their study. Composites at 25% volume fraction showed highest set of mechanical properties.

Khalil *et al.* (2013) used oil palm, bamboo stalk and coconut shell to produce black carbon fiber and studied the tensile, electrical and interfacial properties of black-carbon reinforced epoxy resin based composites. They incorporated 5% volume fraction of filler when preparing the composite materials. Enhanced tensile properties were found for black-carbon from natural source reinforced epoxy resin based composites.

Binoj (2015) obtained natural fibers from Areca fruit. They fabricated composites by hand lay-up technique sequenced by compression molding with unsaturated polyester resin as matrix material. They figured out the mechanical properties of areca fruit fiber reinforced unsaturated polyester resin based composites on different fiber loading. Their results exhibited better mechanical properties for 40 wt% fiber content.

Kushwaha & Kumar (2010) carried out a study on bamboo fiber reinforced epoxy resin based composites. The mat of bamboo fibers were treated with different silane and then fabricated the composites. They were dealt with the mechanical properties. A comparison of treated and untreated bamboo fiber reinforced epoxy resin based composites was made by them. Better tensile strength was found in case of treated bamboo fiber composites over that of untreated ones. But the elastic modulus of untreated bamboo fiber composites exhibited better value than treated fiber composites. It was observed in their study that alkali treated bamboo fiber composites showed better tensile strength than the composites of mercerized bamboo fiber treated with silanes.

Ramesh *et al.* (2013) analyzed a study on the mechanical properties of treated and untreated borassus fiber reinforced epoxy resin based composites. They modified the fiber surface with 5% NaOH and fabricated the composites with different fiber loadings. The composites were prepared by hand lay-up technique where the fiber proportions were varied from 4% to 24% by weight. They reported the improved mechanical properties were obtained for treated borassus fiber reinforced epoxy resin based composites.

The effect of treatment time on kenaf fiber was experimented by Williams *et al.* (2011). The immersion time of kenaf fiber into the solution of 7% NaOH was varied from 30 minute to 24 hours. They demonstrated better values of mechanical properties in case of 16 hours of fiber treatment.

Venkateshwaran *et al.* (2012) conducted a research work on the tensile strength and modulus of short hybrid-natural fiber composite materials. The composites were prepared by using blended banana and

sisal fiber. RoHM was also applied on hybrid composites and the results were agreed experimentally.

Goud and Rao (2011) analyzed the mechanical, electrical and non-conductor properties of roystonearegia fiber composites. They treated the composites with 5% NaOH to check out its effect. The fiber proportion in fabricated composites was 20% by weight where the fibers were oriented unidirectionally in the composites. Reduced water uptake and electrical conductivity was observed due to treating the composites with alkali. But the comprehensive properties were increased significantly as they reported. Faris *et al.* (2014) used palm fiber to fabricate natural fiber composite materials. They observed improved technical properties and suggested to use these composites in automobile industry. The performance of palm fiber composites in automobile was also demonstrated in their study and it was good. They also narrated the advantages of palm as natural fiber composites in automobile application from the perspective of environmental, economic and social aspects.

The mechanical properties and water uptake profile of treated and untreated agave fiber reinforced epoxy resin based composites were studied by Mylsamy and Rajendran (2011). The surface of agave fiber was treated with the concentration of 5% NaOH for 30 minutes. The composites were fabricated by using simple hand lay-up technique. The fiber proportion in fabricated composites was 35% by weight. Improved mechanical properties were noticed in case of treated agave fiber reinforced epoxy resin based composite over that of untreated composites.

Boopalan *et al.* (2013) fabricated hybrid composites by using jute and banana fiber with the epoxy polymer matrix. They reported the composites with 50% fiber content by weight exhibited improved thermal and mechanical properties. The similar fiber content hybrid jute and banana fiber reinforced epoxy resin based composites showed better thermal stability according to their observation.

The effects of fiber loading and alkali treatment on sisal fiber reinforced epoxy resin based composites were evaluated by Padmavathi *et al.* (2012). Sisal fibers were treated with different five concentration of NaOH. They fabricated sisal fiber reinforced epoxy resin based composites with six different fiber proportions. Fibers treated with 18% NaOH and at 40% fiber loading by weight revealed highest set of mechanical properties. The tensile strength, impact strength and compression potential were increased to 27%, 15% and 18% respectively as they reported in their study.

FIBER MODIFICATION FOR COMPOSITE FABRICATION

When the researchers commenced to convert the plant or natural fiber into composites materials, they figured out two challenges. One was the surface integrations and another was the water absorption of natural fiber. To overcome these obstacles, they resorted to chemical treatment of natural fibers.

A noticeable demerit of natural fiber is hydrophilicity. The polarity of natural fibers turn them to hydrophilic nature. This hydrophilic nature of natural fibers acts as a barrier to form interfacial interaction or bonding between fiber and matrix while preparing the fiber reinforced polymer based composite materials. It also weakens the mechanical properties of natural fibrous composites. So it is a major problem to take in consideration. The solution of this problem can be the chemical treatment. The surface of natural fiber can be modified chemically to make it less water absorber.

Farsi (2010) conducted a research work on the effect of chemical modification of wood flour and evaluated the mechanical behavior like tensile, flexural and Izod impact of wood flour reinforced polypropylene based composites. Chemical modification of wood flour was done with silane, acrylic acid and benzoyl chloride, and PP-g-MA coupling agent for making the composites. The used concentration of these chemicals was 3% by weight. Untreated wood flour composites were also prepared in the study to compare with the treated composites. Comparisons were also made with the matrix polypropylene. The composites were fabricated by injection molding method. Improved and peak values of tensile and bending properties were noticed in case of treated with alkali and coupling agent wood flour composites. But lower impact strength was reported for all modified composites. Augmented mechanical properties were observed due to treating wood flour with chemical according to this article. The interfacial interaction between wood flour and polypropylene was also increased as a consequence of chemical treatment that led to better mechanical behavior.

The effects of chemical treatment on the mechanical and thermal properties of okra fiber reinforced polymer based composites were evaluated by Hossain *et al.* (2013). The fibers were treated with 2% sodium hydroxide (NaOH), 4% chromium sulfate ($\text{Cr}_2(\text{SO}_4)_3 \cdot 12 \text{H}_2\text{O}$) and a solution of chromium sulfate and sodium bicarbonate ($4\% \text{Cr}_2(\text{SO}_4)_3 \cdot 12(\text{H}_2\text{O}) + \text{NaHCO}_3$). Tensile, structural and thermal properties of untreated and treated okra fibers were plotted in their study. The appearance of hydroxyl group

(-OH) was assured after Fourier transform spectroscopy analysis. Okra fibers exposed rougher surface due to alkali treatment as they reported. A thin coating on the fiber surface was discovered in rest of the cases according to their study. The single fiber length was varied while determining the tensile strength and modulus. Improved tensile properties of ladies finger plant or okra fiber reinforced polymer based composites were observed after treating chemically. But treated okra fibers showed decreased tensile modulus over that of untreated ones but behaved reversely in case of tensile strength. Thermal stability of treated and untreated okra fibers were also determined by thermo gravimetric analysis in their research work. No change of thermal stability was occurred for both treated and untreated fibers as they reported.

Kalia *et al.* (2009) reviewed about the pretreatments of natural fiber and their implementations as fortified element of fiber polymer composites. They narrated that natural fiber reinforced polymer based composite materials possess a several amenities such as lower weight, non-frictional, inflammable, toxic free, cost effective and degradable in environment. Flax, bamboo, sisal, hemp, ramie, jute and wood fibers have received much attention for recent years among the natural fibers. A variety of composites have been made over the years on natural fiber reinforced polymer composite materials as seen in several research works. Some negative issues like bad interfacial bonding, easy decompose to heat and high moisture absorbency demotivate the use of natural fibers as reinforcing element in composite materials. For overcoming these problems, surface treatment or modification of natural fibers is required to resist the water absorption and increase the surface asperity. Graft copolymerization and plasma treatment are narrated as best way to modify the surface of natural fibers. Treated graft copolymers of natural fibers with vinyl monomers exhibited better fiber matrix adhesion according to their review paper.

Malkapuram *et al.* (2009) stated that the natural fibers have a great percentage of cellulose and behaved friendly to the environment. But dusty constructional fiber or contaminated fiber and unexpected amount of hydroxyl group step behind the potentiality of natural fiber. It is also acted as obstacle to form the composite materials. The natural or plant fibers are grouped altogether by lignin and pectin. These lignin and pectin are poor in strength than cellulose. That's why a necessity to remove lignin and pectin is come forward for achieving an utmost fortified effect. In order to remove water absorption and surface toughness of natural fiber chemical treatment is must as they reported.

A study of mechanical properties analysis of treated and untreated natural fiber composites was carried out by Arrakhiz *et al.* (2013). Before fabricating the bagasse, alfa and coir fiber reinforced polypropylene based composites, the fibers were subjected to alkali treatment in order to remove non cellulosic components. In this way improved mechanical properties were achieved according to the report.

The surface modification of *Prosopis juliflora* fibers was carried out by Saravanakumar *et al.* (2014) 5% concentration of NaOH by volume fraction was used for treating the *Prosopis juliflora* fibers. They observed the effect of soaking time into alkali solution and got to know 60 minutes gave the optimum output. Improved thermal, physical and chemical properties were imparted to the fibers due to alkali treatment that made the *Prosopis juliflora* fibers suitable for reinforcing or fortifying element of *Prosopis juliflora* fiber reinforced polymer based composite materials.

Kommula *et al.* (2013) extracted napier grass fiber and showed the effect of alkali treatment on the mechanical, physical, thermal and chemical properties. They treated the fibers into alkali solution and fabricated composites with three variation of fiber proportion. They found that the optimum level of surface modification was achieved while treating the fibers with 5% NaOH solution by volume fraction for 2 hours.

Wang and Huang (2009) conducted a research work on treated coir fibers. The used solution of sodium hydroxide was varied from 2% to 10% by volume. The tensile performance of treated coir fibers were evaluated to check out the effect of alkali treatment. Results demonstrated that the tensile strength of test specimen was declined with the increase of alkali concentration. Treated with 10% NaOH exhibited lowest tensile strength according to their study. They noticed no remarkable changes of tensile performance while treating the test specimen with 2%, 4%, 6% and 8% NaOH.

Ramaiah *et al.* (2011) experimented the effect of surface modification on mechanical performances of *Sansevieria* leaves. They treated *Sansevieria* leaves chemically with 5% sodium hydroxide. Their results demonstrated improved thermal and mechanical characteristics due to alkali treatment. On the other hand Ray and Sarkar treated jute fibers with the same concentration of alkali solution. But the immersion time of jute fiber into the alkali solution was varied from 0 to 8 hours. They found significant augmentation of properties within the time range of 2 to 4 hours. Fourier transform infrared spectroscopy and X-ray diffraction

were carried out to figure out the change of characteristics.

Izani *et al.* (2012) figured out the effect of alkali treatment on EFB fiber. They analyzed the tensile performance and interfacial properties of EFB fiber. The alkali solution was made with 2% concentration of NaOH and the rest of the solution was boiled water. The interfacial properties were examined by scanning electron microscope (SEM). The loss of weight of fiber due to treating into hot solution of NaOH was determined by Thermo gravimetric analysis (TGA). The properties of fiber were enhanced as consequence of alkali treatment according to their report.

Singha & Thakur (2009) carried out silane treatment on natural fiber to modify the fiber surface. Surface modification of natural fiber is very essential to remove impurities as well as reduce moisture absorption tendency according to the study. The surface roughness of natural fiber can also be increased by silane treatment resulting in improve adhesion between fiber and matrix. Particularly silane treatment for surface modification is very effective for lignocellulosic natural fiber.

CONCLUSION

An overview of natural fiber reinforced composites, its composition, surface modification, and the impact of chemical treatments on natural fiber composites have been discussed in this study. Numerous treatments demonstrate the notable improvements in the mechanical properties of the natural fiber reinforced composites including tensile strength, tensile modulus, flexural strength, flexural modulus, and elongation percentage and water absorption. The results of different study indicate that natural fiber composites with an alkali surface modification have superior tensile and flexural strength than untreated composites.

By modifying or treating the surface of the natural fibers, contaminants such as lipids, lignins and pectins can be eliminated. As a result, the water absorption capability of natural fiber reinforced composites is reduced and the adhesion force between the fiber and matrix is enhanced. In the realm of fibrous composite materials, natural fiber reinforced polymer based composites and their variations show significant promise and have a bright future.

Conflict of Interest

The authors declare no conflicts of interest.

REFERENCES

- Arrakhiz, F. Z., Malha, M., Bouhfid, R., Benmoussa, K., & Qaiss, A. (2013). Tensile, flexural and torsional properties of chemically treated alfa, coir and bagasse reinforced polypropylene. *Composites. Part B, Engineering*, 47, 35–41.
- Binoj, J. S. (2015). Optimization of short Indian Areca fruit husk fiber (Arecacatechu.L)-reinforced polymer composites for maximizing mechanical properties. *Int. J. Polym. Anal. Charact*, 21(2), 112–122.
- Boopalan, M., Niranjanaa, M., & Umapathy, M. J. (2013). Study on the mechanical properties and thermal properties of jute and banana fiber reinforced epoxy hybrid composites. *Compos. B Eng*, 51, 54–57.
- Doherty, W. O. S., Mousavioun, P., & Fellows, C. M. (2011). Value-adding to cellulosic ethanol: Lignin polymers. *Ind. Crops Prod*, 33(2), 259–276.
- Faris, M., Al-Oqla, F. M., & Al-Oqla, S. M. (2014). Natural fiber reinforced polymer composites in industrial applications: feasibility of date palm fibers for sustainable automotive industry. *J. Clean. Prod*, 66, 347–354.
- Farsi, M. (2010). Wood-plastic composites: influence of wood flour chemical modification on the mechanical performance. *Journal of Reinforced Plastics and Composites*, 29(24), 3587–3592.
- Fiore, V., Sanfilippo, C., & Calabrese, L. (2020). Dynamic mechanical behavior analysis of flax/jute fiber-reinforced composites under salt-fog spray environment. *Polymers*, 12(3), 716.
- Goud, G., & Rao, R. N. (2011). The effect of alkali treatment on dielectric properties of Roystonea regia/epoxy composites. *Int. J. Polym. Anal. Charact*, 16(4), 239–250.
- Hoque, M. B., Mollah, M. Z. I., Faruque, M. R. I., Hannan, M. A. & Khan, R. A. (2021). Review on the Mechanical Properties of Pineapple Leaf Fiber (PALF) Reinforced Epoxy Resin Based Composites. *Engineering and Technology Journal*, 6 (4), 855-860.
- Hossain, S. I., Hasan, M., Hasan, M. N., & Hassan, A. (2013). Effect of chemical treatment on physical, mechanical and thermal properties of ladies finger natural fiber. *Advances in Materials Science and Engineering*, 1–6.
- Izani, M. A., Paridah, M. T., Anwar, U. M. K., Mohd Nor, M. Y., & Ng, P. S. (2012). Effects of fiber treatment on morphology, tensile and thermogravimetric analysis of oil palm empty fruit bunches fibers. *Compos. B Eng*, 45(1), 1251–1257.
- Kalia, S., Kaith, B. S., & Kaur, I. (2009). Pretreatments of natural fibers and their application as reinforcing material in polymer composites-A review. *Polymer Engineering & Science*, 49(7), 1253–1272.
- Khalil, H., Jawaid, M., Firoozian, P., & Amjad, M. (2013). Tensile, electrical conductivity, and morphological properties of carbon black-filled epoxy composites. *Int. J. Polym. Anal. Charact*, 18(5), 329–338.
- Kushwaha, P. K., & Kumar, R. (2010). Effect of Silanes on mechanical properties of bamboo fiber-epoxy composites. *Journal of Reinforced Plastics and Composites*, 29(5), 718–724.
- Ludueña, L., Vázquez, A., & Alvarez, V. (2012). Effect of lignocellulosic filler type and content on the behavior of polycaprolactone based eco-composites for packaging applications. *Carbohydrate Polymers*, 87(1), 411–421.
- Malkapuram, R., Kumar, V., & Negi, Y. S. (2009). Recent development in natural fiber reinforced polypropylene composites. *Journal of Reinforced Plastics and Composites*, 28(10), 1169–1189.
- Mohanty, A. K., & Misra, M. (2012). Engineered natural fiber reinforced polypropylene composites: Influence of surface modifications and novel powder impregnation processing. *J. Adhes. Sci. Technol*, 16(8), 999–1015.
- Murugan, R., & Jeyaraj, P. (2017). Mechanical properties of natural fiber braided yarn woven composite: Comparison with conventional yarn woven composite. *Journal of Bionic Engineering*, 14(1), 141–150.
- Musa, C., Kervoëlen, A., Danjou, P.-E., Bourmaud, A., & Delattre, F. (2020). Bio-based unidirectional composite made of flax fibre and isosorbide-based epoxy resin. *Materials Letters*, 258(126818), 126818.
- Myksamy, K., & Rajendran, I. (2011). The mechanical properties, deformation and thermomechanical properties of alkali treated and untreated Agave continuous fibre reinforced epoxy composites. *Materials in Engineering*, 32(5), 3076–3084.
- Ng, L. F., Dhar Malingam, S., Selamat, M. Z., Mustafa, Z., & Bapokutty, O. (2020). A comparison study on the mechanical properties of composites based on kenaf and pineapple leaf fibres. *Polymer Bulletin (Berlin, Germany)*, 77(3), 1449–1463.
- Nopparut, A., & Amornsakchai, T. (2016). Influence of pineapple leaf fiber and its surface treatment on molecular orientation in, and mechanical properties of, injection molded nylon composites. *Polymer Testing*, 52, 141–149.

- Padmavathi, T., Naidu, S. V., & Rao, R. (2012). Studies on mechanical behavior of surface modified sisal fibre – epoxy composites. *Journal of Reinforced Plastics and Composites*, 31(8), 519–532.
- Ramanaiah, K., Ratna Prasad, A. V., & Chandra Reddy, K. H. (2011). Thermal and mechanical properties of Sansevieria green fiber reinforcement. *International Journal of Polymer Analysis and Characterization*, 16(8), 602–608.
- Ramesh, M., Palanikumar, K., & Reddy, K. H. (2013). Mechanical property evaluation of sisal–jute–glass fiber reinforced polyester composites. *Composites. Part B, Engineering*, 48, 1–9.
- Saravanakumar, S. S., Kumaravel, A., Nagarajan, T., & Moorthy, I. G. (2014). Effect of chemical treatments on physicochemical properties of Prosopis juliflora Fibers. *Int. J. Polym. Anal. Charact*, 19(5), 383–390.
- Sathishkumar, T. P., Navaneethakrishnan, P., Shankar, S., Rajasekar, R., & Rajini, N. (2013). Characterization of natural fiber and composites – A review. *Journal of Reinforced Plastics and Composites*, 32(19), 1457–1476.
- Singha, A. S., & Thakur, V. K. (2009). Grewia optiva Fiber reinforced novel, low cost polymer composites. *E-Journal of Chemistry*, 6(1), 71–76.
- Singha, A. S., & Thakur, V. K. (2010). Synthesis, characterization and study of pine needles reinforced polymer matrix based composites. *Journal of Reinforced Plastics and Composites*, 29(5), 700–709.
- Summerscales, J., Dissanayake, N. P., Virk, A. S., & Hall, W. (2010). A review of bast fibres and their composites. Part 1: Fibres as reinforcements. *Compos. Part A: Part A Appl. Sci. Manuf*, 41, 1329–1335.
- Thakur, V. (2013). *Green composites from natural resources*. Boca Raton, FL: CRC Press.
- Thakur, V. K., & Singha, A. S. (2010). Evaluation of GREWIA OPTIVA Fibers as Reinforcement in Polymer Biocomposites. *Polymer-Plastics Technology and Engineering*, 49(11), 1101–1107.
- Tongnunui, A. W. A. (2014). Sustainable green composites of thermoplastic starch and cellulose fibers. *Songklanakar J. Sci. Technol*, 36(2), 149–161.
- Venkateshwaran, N., Elayaperumal, A., & Sathiya, G. K. (2012). Prediction of tensile properties of hybrid-natural fiber composites. *Compos. B Eng*, 43(2), 793–796.
- Vimalanathan, P., Venkateshwaran, N., & Santhanam, V. (2016). Mechanical, dynamic mechanical, and thermal analysis of Shorea robusta-dispersed polyester composite. *Int. J. Polym. Anal. Charact*, 21(4), 314–326.
- Wang, W., & Huang, G. (2009). Characterisation and utilization of natural coconut fibres composites. *Materials in Engineering*, 30(7), 2741–2744.
- Williams, T., Hosur, M., Theodore, M., Netravali, A., Rangari, V., & Jeelani, S. (2011). Time effects on morphology and bonding ability in mercerized natural fibers for composite reinforcement. *International Journal of Polymer Science*, 2011, 1–9.
- Zhang, Q., Bulone, V., Ågren, H., & Tu, Y. (2011). A molecular dynamics study of the thermal response of crystalline cellulose I β . *Cellulose (London, England)*, 18(2), 207–221.
- Zhao, S., Yin, J., Zhou, K., Cheng, Y., & Yu, B. (2019). In situ fabrication of molybdenum disulfide based nanohybrids for reducing fire hazards of epoxy. *Compos. Part A Appl. Sci. Manuf*, 122, 77–84.

--0--