Surface Impurities removal on the natural fibers by using various chemical treatments - A Review

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Abstract - **This paper well-defined several chemical treatment methods implemented on the different fiber surfaces and its effect on the impurities removal rate. As of late, there have been a few endeavors to supplant engineered strands with regular filaments in fiber fortified composites, because of expanding natural mindfulness and consumption of oil assets. The way that normal filaments are accessible efficiently and in plenitude, being biodegradable and low thickness, has spurred numerous scientists all through the world to investigate their application potential in different modern areas. In any case, common strands likewise have a few restrictions, for example, high dampness ingestion and resulting swelling and debasement, poor substance and imperviousness to fire, high scattering of mechanical properties, poor interfacial collaborations with polymeric or cementitious frameworks, and so on. Consequently, there is a tremendous worry to adjust the outside of normal filaments through different procedures, so as to beat their characteristic disadvantages and to effectively use these materials in different applications. This paper introduces a survey of existing exploration ponders concentrated superficially treatment of common strands and the utilization of nano cellulose, a characteristic nanofiber, for their application in composite materials.**

keywords - **Natural fibers, Chemical Treatments, Surface Impurities, and mechanical properties**

I. INTRODUCTION

Because of the uncertainties about atmosphere condition refuge and financial related issues, normal strands have turned out to be intriguing and interesting these days. To be sure, the emphasis is on utilizing characteristic strands as a modern material, for example, sports gear, car application furthermore, development material for basic and non-basic components. These days, because of ecological concerns and monetary issues of engineered strands, normal filaments or bio-strands are intriguing to be utilized as fortification filaments in polymer composites for basic components of development materials. Compound surface adjustment strategy is an outstanding technique to increment the interfacial holding quality among strands and polymer framework. The antacid treatment of kenaf fiber may influence the surface as well as the surface of fiber bringing about the variety of mechanical and physical properties [1]. The impacts of fiber substance, fiber measure, concoction treatment, temperature and dampness content on the dielectric properties of the conductive composites were surveyed. Then again, it was accounted for that generally short regular strands could alter the dielectric reaction of the polymeric framework, yet substance treatment effects affected such composites and could diminish the dielectric misfortune factor [2]. The compound structure of the characteristic strands as far as cellulose, hemicellulose, lignin, and cinder substance was determinate by utilizing standard test techniques. The mechanical portrayal was helped out through single-fiber elastic tests and a dependability examination of the test information was performed. Moreover, a numerical model was connected to research the connection between the transverse component of the filaments and the mechanical properties [3]. Since archaic times, normal strands have been utilized for getting ready dividers, crates, ropes, garments and a lot more items. All the more as of late, regular strands, for example, jute, kenaf, sisal, hemp, and flax have been utilized in the building generation field. Characteristic fiber composites are utilized progressively in aviation and car productions. These days, scientists are contrasting regular fiber composites and counterfeit composites, to locate the most fitting materials for designing fields. Specialists are additionally increasingly centered around characteristic strands because of their biodegradability and low generation cost. Appraisals of the materials utilized in airplane parts and board structures have been made to contemplate the capability of utilizing regular fiber composites [4]–[6]. Every single connected treatment brought about a decrease in the water assimilation limit and increment in rigidity. Noteworthy upgrades in the fiber– bonding interface was confirmed through the pullout test for the few utilized medications. The hornification treatment expanded the versatile and frictional bond, though the polymer and half-breed medicines brought about a fiber slip-strengthening conduct [7]. The different surface treatments on the natural fiber reduced the surface impurities on the fiber within the specified limit of the chemical treatment percentage. The chemical treatment percentage when it considerably increases after the fixed range of percentages, it produces the damage on the fiber internally as cell wall damaged, micropores on the fiber and fiber crushed. The fiber properties, as well as fiber, reinforced composites properties improved due to the chemical treatment. [18-21].

II. NATURAL FIBERS

Natural based fibers are created by plants, creatures, and topographical processes. They can be utilized as a segment of composite materials, where the introduction of filaments influences the properties. Natural filaments can likewise be tangled into sheets to make items, for example, paper felt or texture. Natural fibers are great perspiration sponges and can be found in an assortment of surfaces. Cotton yarns produced using the cotton plant, for instance, produce textures that are light in weight, delicate in the surface, and which can be made in different sizes and hues. Garments made of common filaments, for example, cotton are regularly favored overdress made of manufactured strands by individuals living in hot and sticky atmospheres. [8], [9].

III. Mechanical Properties of the Natural fibers

Table 1. Mechanical properties of few natural fiber [Source: Reza Mahjoub et al 2014]

Fiber	Density (g/cm3)	Tensile strength (MPa)	Elastic modulus (GPa)	Elongation at break (%)
Jute	1.3	393–773	26.5	1.5–1.8
Sisal	1.5	511–635	9.4–22	2.0–2.5
Flax	1.5	500–1500	27.6	2.7–3.2
Hemp	1.47	690	70	2.0–4.0
Pineapple	1.56	170–1627	60–82	2.4
Cotton	1.5–1.6	400	5.5–12.6	7.0–8.0
Kenaf	1.45	930	53	1.6

The mechanical properties of the various natural fibers were mentioned in table 1.the tensile strength and elastic modulus for pineapple, kenaf, flax, and jute were higher than the other natural fibers [1].

IV. Effect of Chemical Treatment for Surface modifications on the fiber

The NaOH treatment of kenaf fiber may influence the surface as well as the surface of fiber bringing about the variety of mechanical and physical properties. This examination was directed to discover the impacts of various conditions of antacid treatment as far as the convergence of salt arrangement and drenching time on the fiber properties. For this examination, 360 fiber examples were tried for 24 different states of introductory treatment also, antacid surface adjustments. the outcomes were examined and detailed by utilizing three strategies including relapse technique, averaging the information and framework consistency strategy. In addition, the checking electron microscopy was utilized to watch the examples' appearance, crack territory and filaments' measurement. The result from the examination found that the normal breadth of untreated kenaf fiber was 67.6 lm, the thickness was 1.2 g/cm3 and the elasticity was 780 MPa. In addition, the 5% soluble base solution was the best for kenaf fiber treatment in light of causing no pressure on the fiber surface and structure when contrasted with 10% and 15% soluble base arrangement [1].

It was observed that the untreated sample demonstrated the most noteworthy dielectric steady qualities contrasted with the treated ones. It was likewise revealed that all utilized synthetic medications diminished the dielectric steady just as the misfortune factor. Variety of dielectric steady of sisal/polyester composites as the capacity of fiber substance and recurrence at 30oC. Variety of proportional of dielectric consistent as a component of fiber content (vol.%) at various frequencies.50 F.M. AL-Oqla et al. /Synthetic Metals 206 (2015) 42– 54 MAPP treated composites demonstrated the least dielectric consistent esteem. The scientists related that impact to the capacity of the treatment that diminished the hydrophilic idea of jute yarns by decreasing the dampness ingestion. It caused a decrease in the orientational polarization that prompted lower dielectric consistent and misfortune factor esteems. Plus, the substance treatment could diminish the number of voids and different anomalies that prompted abatement of the water ingestion and henceforth the dielectric steady [2-3].

They contemplated the impact of concoction alteration just as fiber stacking on the composites especially, their thermophysical and dielectric properties. Additionally, the dielectric consistent of the composites was observed to be higher than that of polypropylene. It additionally appeared that the support of flax fillers in the polypropylene expanded the relative dielectric permittivity. In addition, the composites of banana, hemp, and agave (both treated with maleic anhydride and untreated cases) with high thickness polyethylene (HDPE) sap were independently studded for both surface and volume resistivity with extraordinary fiber stacking conditions. It was accounted for that the surface resistivity diminishes, though volume resistivity increments with an expansion in fiber content in the composites. The impact of synthetic treatment on the volume resistivity of various proportions of common strands/HDPE is appeared [4-5]. Surface impurities on kenaf fiber were finished by fading with hydrogen peroxide under basic conditions. This treatment caused an expansion in the crystallinity file and surface harshness of the kenaf fiber because of the expulsion of lignin and hemicellulose after the blanching treatment. The expansion in surface harshness of the kenaf fiber made great interlocking with the PLA framework, henceforth, it modified the interfacial attachment among PLA and fiber. Therefore, the mechanical properties of PLA/faded kenaf fiber composites (BC) are changed [6].

The soluble treatment of kenaf fiber with 10% and 15% NaOH preparation harmed the surface of fiber as the treated fiber is progressively turned, a lot better thus weak than the untreated fiber. Therefore, these convergences of NaOH answer for antacid treatment are not prescribed. Scanning electron microscope (SEM) was used to observe the surface morphology of the fiber surface. It was observed that due to the chemical treatment, the fiber obtained a rough and clean surface which aids in the interfacial bonding between the kenaf fiber and polymer. Untreated fiber consisted of wax, lignin, and hemicellulose which got removed from the surface area as a result of the chemical treatment. The results obtained also showed that the concentration of NaOH of about 10% damaged the structure of the fiber.[1]

The cellulose fraction present in the fiber increased due to the removal of other impurities by using the alkali treatment. The crystallinity value of the cellulose was observed by using the X-ray diffraction technique and it was observed that there was an increase due to the alkali treatment. The highest density value was shown by the alkali-treated fiber when compared with the untreated fibers. The fibers were subjected to silane treatments where it showed fewer mechanical properties than the untreated fibers. This is because the acid present in silane treatment catalyzed the bonds. During alkali treatment, voids were created in the internal structure of the fiber and due to this the young's modulus and tensile strength decreased. These voids could be filled by using low viscosity oils like the canola oil. The combination of NaOH and silane treatment further increased these voids by removing non-cellulosic constituents and hence these reduced the mechanical properties of the fibers. This reduction in mechanical properties is because the cellulose molecules are exposed to the acid present in the silane treatment and hence shorter cellulosic chains are obtained [8].

Silane treated fibers obtained more interfacial bonding. Using higher concentration for the chemical treatment may remove the impurities efficiently but it reduces the tensile strength due to the rupture of the fiber surface. Silane treatment under the right amount of concentration showed greater results than other treatments but in case of PLAF, other treatments showed near to no change [9] The SEM image of both untreated and alkali-treated abaca fibers were studied and the hollow lumen was visible in the untreated fibers of 250-300υm diameter whereas no lumen was visible on the treated fibers and also the fiber diameter decreased following the alkali treatment. The lumen almost disappeared because of the swelling of the fibers and also because the lumen collapsed into the alkali solution. This increase in the alkali concentration also increased shrinkage and weight loss. It was observed that at 5% NaOH treatment of the abaca fiber, the fiber bundles appeared as twisted bundles and on the addition of 10-15% NaOH the bindings collapsed. Hence the higher concentration of treatment collapsed the integrity and this amount of concentration of alkali treatment is deemed unfit for abaca fibers[10].

The SEM image of treated and untreated agave and coir fiber were compared and it was found that the surface of this fiber is rough by nature. The fiber surface was treated with maleated polyethylene(MAPE) and it was found that the MAPE penetrated the fiber porosity and significant MAPE was deposited on the fiber surface. These phenomena have a positive effect on the interaction between the fiber-matrix adhesion and dispersion. Treated and untreated pine fibers were compared and it was observed that MAPE was not uniformly deposited on the treated surface. Some gaps and fiber pullout are present in the untreated fibers whereas there were no gaps or any signs of fiber pull out in the case of treated fibers. This change between the fiber-matrix interface of the treated and untreated fibers shows that the surface treatment was effective [11].

Table 2. The outcome of surface chemical treatments on natural fiber [1-29]

Surface Treatments	Effect of Surface Treatments
Alkali	Reduce the lignin content. Improve fiber-matrix adhesion, thermal stability and heat resistivity
Acetylation	Improve tensile and flexural strength
Benzoylation	Improve hydrophobicity
Enzyme	Reduce the lignin content
Grafting	Improve UV-protective properties, hydrophobicity and mechanical properties
Isocyanate	Surface modification
Mercerization	Reduce the moisture regain and improve the mechanical properties
Methacrylate	Improve tensile and flexural strength
Ozone	Affect surface energy and contact angle
Peroxide	Reduce the moisture regain
Plasma	Improve hydrophobicity
Silane	Improve hydrophobic and mechanical properties
Sodium chlorite	Improve tensile strength, young's modulus, and elongation at break

V. Effect of Chemical Treatment on the Tensile properties of fiber

Untreated kenaf fibers showed higher tensile properties when compared with treated kenaf fibers. It was observed from the results that the immersion time greatly affected the tensile properties of the kenaf fibers. When the immersion time was increased from 3 to 24h with 7% alkali solution the tensile strength decreased from 21% to 11%. Similarly, the increase in the concentration of NaOH also reduced the tensile strength from 33% A-T7-24 to 20% A-T5-24. Finally, the conclusion was made that 5% alkali solution immersed for about 3h as the best in terms of tensile strength. Further, the use of chloride-containing clean water is not recommended for the water retting process as the presence of chloride will cause damage to the structure of the fiber [1]. Cellulose is one of the most important components of the fiber and is responsible for the strength, structural and stiffness property. Cellulose is resistant to hydrolysis although the chemical treatment of the fiber reduces its content up to some extent thereby causing a change in the tensile properties [3].

It is observed that there was an increase in the young's modulus and tensile strength when the treatment time was increased to about 120h. After 120h of treatment, the young's modulus keeps on increasing but at the same time, the tensile strength of the chemically treated fiber decreases. Hence treatment times higher than 240h were not studied due to its degradation phenomena. Further kenaf fiber showed a slight decrease in its tensile properties after 48h of alkaline treatment when compared with untreated fibers. The interfacial shear strength is relatively lower in untreated fibers due to the presence of waxy layer around the fiber and hence chemical treatment of the fiber is important. The observed results show that the optimum treatment time is about 120h to improve the fiber-matrix adhesion and any process beyond this time is useless as it causes damage to the fibers. Obi Reddy et al observed that the strength and modulus of the Borassus fruit fiber increased for up to 8h of alkaline treatment after which the fiber showed a deterioration in its properties. This time for the deterioration can be further delayed if a mild alkaline solution is used for the treatment. The removal of hemicellulose and partial removal of lignin according to the morphological analysis showed that the T-24h resulted in about 63.2% increase of tensile strength. Regardless of the time taken for the alkaline treatment, the shear strength was always greater than the untreated fibers[5].FTR analysis was done on kenaf fiber and it was observed that with the addition of 10% of unbleached kenaf fiber, the tensile strength decreased from 53.6MPa to 38.5MPa.On further addition of 40wt%, fiber with a composite resulted in a decrease of tensile strength. Devi et al observed that energy absorption depends upon the adhesion between the fiber and matrix. Poor adhesion of the fiber-matrix composites causes a crack in the composites and hence matrix composite tends to break even under low pressure[6].

In an electromechanical testing machine, tensile test was performed Shimadzu AG-X with a load cell of 1KN. The stress-strain curves of the untreated and treated sisal fibers were compared and it was found that the tensile strength of the sisal fibers increased up to 32% after undergoing alkali treatment. It was later studied and found out that this reason for the increase in strength is due to the removal of impurities and other non-cellulosic materials. The fibers present in the sisal rearrange themselves after the alkali treatment due to the less density of the fiber structure after the treatment. Further, an increase of about 50% in the tensile strength of the fibers was observed after the polymer treatment. Styrene-Butadiene was used in the treatment of polymers and an increase of about 15% was observed in the fiber. The solution gets absorbed by the polymer and after drying the structure becomes more dense and rigid. Higher adhesion was observed in the hornified sisal due to the stiffening of the fiber cell structure, it results in the decrease of the lumen which further reduces the ability of water getting absorbed by the fiber. The roughness of the sisal fibers increased when the alkaline solution of low concentration was used. The hybrid and polymer treatments showed the highest improvements in properties. In a polymer-modified sisal fiber, the SEM image shows that there is a polymer film in between the cement and the fiber matrix. Hence it is postulated that the polymer coating results in the strengthening of the interfacial bonding between them[7].

Treatment of fibers with 6% NaOH is considered to be the best for removing the impurities in PALF and increasing the tensile strength. When the fibers were treated with 2% concentration of silane, the maximum tensile moduli were obtained. The tensile moduli increased by about 105% for treated PALF and by 175% for Kenaf fiber. Low tensile moduli of NaOH treated should be avoided because they cause fiber damage[9]. The alkali-treated abaca fibers were compared with the untreated abaca fibers and it was found that after 5% NaOH treatment the tensile strength increased by about 8% and the youngs modulus by about 36%. After the 5% NaOH treatment, the strain at the break also decreased. This improvement in the youngs modulus and the tensile strength is due to the improved crystallinity between the fibers. Further, the addition of 15% alkali treatment decreased the youngs moduli by 49% despite maintaining high tensile strength. The stiffness of the treated fibers increased but the toughness decreased when compared to untreated fibers[10].

In the case of untreated fibers, the tensile moduli decreased to about 30-40% of the fiber content. Tensile modulus improves due to the rigid phase present in the matrix and hence this decrease in moduli is due to the roto-molding process used and also due to fiber agglomeration. The surface treatment of agave and coir composites by using maleated polyethylene led to an increase in the tensile strength.20% was found to be the optimum level. The treatment showed greater increment when compared with the untreated fibers. Tensile modulus increased from 18 to 91MPa for treated agave fiber consisting of about 40% fiber content. Poor adhesion is the reason for the decrease in the tensile strength of the untreated fibers. The surface treatment for coir and agave fiber consisting of the low fiber content of about 10-20% showed substantial changes in their properties. The tensile strength increased from 37%-55%, these results show that the fiber-matrix adhesion was obtained[11]. The increase in the strength of the composite can be explained due to the addition of alkaline treated fibers. The alkaline treated fibers undergo a change in their hydrogen bond present in the network structure. The alkaline treatment created a clean and compact fiber surface[17].

VI. EFFECT OF CHEMICAL TREATMENT ON THE DIMENSIONS OF THE FIBER:

Based on the observation between the 5% and 7% alkaline treated kenaf fibers it was found that the diameters of the fibers varied from 29 m to about 120 m it was found that the average diameter of kenaf fibers was about 67.6 m. From the comparison of 10 % and 15% alkaline treated fibers it was found that the fiber texture was damaged and the fibers were brittle and twisted. This led to the conclusion that 10 and 15% NaOH treatment was not suitable for the fiber [1]. The diameter and the density of the sisal fibers were determined by the Weibull distribution fitting and helium pycnometer respectively. It was observed that the density of the fibers did not change whereas the diameter of the fiber was influenced by the treatment. The diameter of the fiber decreased with an increase in the duration of the treatment. The aspect ratio of the raw fibers was 123.7 while the aspect ratio of the treated fibers was observed to be 214.6. this aspect ratio increment is one of the most influential parameters for the determination and governing of mechanical properties of short fibers reinforced polymer composites. Through Fourier transform infrared spectrometry analysis it was found the reduction in the diameter of the fiber was due to the removal of waxy substances covering the external fiber surface[2].

VII. EFFECT OF CHEMICAL TREATMENT ON THE FLEXURAL PROPERTIES OF THE FIBER:

The addition of epoxy resin to the raw sisal fibers increase the flexural modulus whereas it caused a reduction in the flexural strength of the fiber. this caused an increase in the stiffness value of the fiber due to the addition of rigid fibers into the epoxy resin. The flexural strength is affected by the weak adhesion between the untreated lignocellulosic fibers and the thermosetting resins. A slight reduction in the flexural modulus can be observed after 24 hours of treatment but the strength increases by 28.7% compared to the untreated fiber-reinforced composites. this shows that the treatment time is not enough for both the strength and modulus to reach the maximum value. Further analysis shows that the treatment time of 120 hours is optimum for the fiber to attain maximum flexural strength and modulus values and also improves the fiber/matrix adhesion and interface quality. Further on increasing the alkaline treatment time will damage the fibers and will decrease the effectiveness of the treatments on the fiber[5].

kenaf fibers were added with polylactic acid and they were subjected to bleaching treatment. The flexural strength decreased with the addition of kenaf fibers into the pure polylactic acid. However, when the content of the fibers increased from 10 to 30wt%, both the treated and untreated composite showed an increase in flexural strength. This shows that the treated composite has higher flexural strength at each fiber loading than the untreated composite. Huda et al observed that the increase in the flexural strength of the fiber was mainly due to the good compatibility between matrix and fiber[6]. The flexural strength and the modulus of the hemp fiber-reinforced composite were observed. The three-point bending test was used to measure the influence of the treatment on the fiber composite. The result obtained showed that the 5% silane treatment resulted in the increase of both the flexural strength and modulus of the fiber composite. The 5% silane treated fiber showed the modulus value of about 4186MPa, this was greater when compared to 5% NaOH treated fiber which showed a modulus value of about 3694MPa only. Similarly, the flexural strength was greater for silane treated fibers than the NaOH treated ones. Thus, in the case of hemp fiber silane treatment was found to be more effective than any of the alkaline treatment [15].

VIII. EFFECT OF CHEMICAL TREATMENT ON THE WATER ABSORPTION CAPACITY OF FIBERS:

The capacity of sisal fibers to absorb water for the different treatments were studied. It was observed that there was a major decrease in the water absorption of the sisal fiber after immersion of the fiber for 1 hour. Sisal fiber under its dry state can absorb water content of about 200% of its own weight. This tendency for the sisal fiber to absorb water is due to the presence of hemicellulose in its structure, crystalline cellulose and Lignin are the other elements which play an important role during the absorption of water by sisal fiber. The sisal fibers start swelling up due to the absorption of water because the water occupies the free space between the fibrils. any kind of chemical treatment on the natural fiber caused a decrease in the absorption of the water quantity by the fiber. The reduction rate was about 15% for the alkali-treated fiber. This is due to the reduction in the quantity of hemicellulose and lignin present in the fiber structure. The chemical treatment also causes a change in the chemical bond of the fiber which makes them more hydrophilic. The packing of fiber cells gets increased after several wetting and drying cycles. This causes a reduction in the lumen content which reduces the water absorption by the fiber.This water absorption capacity can be further decreased by using a polymer that creates a coating layer over the fiber walls. The polymer fills the gap between the cells of the fiber and decreases water absorption[7].Microcracks are responsible for the absorption of the water by the fiber. If there are micro cracks present in the polymer matrix then the water will penetrate into the fiber structure. Whereas the gaps in the molecular chain cause inward diffusion[16].The water absorption capacity of various amounts of untreated and treated grass fiber combined with polylactic acid was studied. It found that the neat poly lactic acid showed about 0.88 percent absorption of water after immersing it for 48 hours. The elephant grass fiber was used with polylactic acid to form a composite. Polylactic acid is a hydrophobic polymer whereas elephant grass fiber is hydrophilic in nature because it contains a large amount of hydroxyl group in its structure.The water absorption of the composite increased gently for the first 24 hours and then the absorption of water leveled off. The amount of water absorbed increased with an increase in the amount of elephant grass fiber. At 25% weight fraction of 11.17% water was absorbed. This amount of water absorption is due to the strong hydrophilic nature of the elephant grass fiber. Alkali treated elephant grass fiber observed a decrease in the water absorption percentage. Only 6.05 % of water was absorbed by the fiber at Higher fiber loading. The water absorption of the fiber decreased with the increase in the alkali treatment concentration. This is due to the reaction of alkali with a hydroxyl group which resulted in the hydrophobic nature in the fiber [17].

IX. CONCLUSION

This review paper gone concluded the detailed survey of the chemical effects on the natural fiber surface. The various chemical treatments considered for the study; the chemicals were played a major role in the removal of surface impurities on the natural fiber. Each chemical had unique properties that used to apply on fiber surfaces. The NaOH (It means 'Alkali') solution made drastic changes when removals of surface impurities on the Natural Fibers. The chemical treatments applied on the fiber surface drastically changed its properties in an effective manner and improved all the properties. The product manufactured after chemical treatment made in the natural fiber was withstood the more load and quality of the product was also efficient.

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