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The Changes on Morphological and Absorption Ability of Treated Corn Stalk Fiber

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Abstract. Natural fiber like corn stalk fiber nowadays can be used to replace synthetic fiber. However, their natural properties may influence their performance which making hem limited to use. In this research study, variety types of chemical treatment which economical technique was used to modified the physical and chemical properties of corn stalk fiber. After the treatment process, the surface morphology and water absorption ability of the fiber was examined. There was an improvement on surface morphological by making them clean and rough compared to untreated corn stalk fiber. The hydrophobicity of corn stalk fiber also increased after treatment. As we can see, H₂SO₄-treated fiber has lowest water absorption ability compared to others. By removing the unnecessarily element on the fiber which comparable with synthetic fiber may increase their potential to become first choice as reinforcement materials in composite industries later.

1. Introduction

There are many researcher and industries nowadays switching their research topics from synthetic fiber into natural fiber. Besides that, the agricultural-based industries produced the vast amount of residues every year, which released to the environment without proper disposal procedure causing the environmental pollution and harmful effect on human and animal health [1]. The increasing environmental concerns, depletion of petroleum resources and growing global waste problems have increased the importance of natural fibers once again and have stimulated researchers to use sustainable fibers instead of conventional synthetic fiber [2].

The natural fibers may come from a variety sources. They can be extracted from the different parts of the plant such as stem (*Cissus quadrangularis*, *Humulus lupulus L.*, *Lygeum spartum L.*, and *Arundo Donax L.*), fruit (*Gossypium arboreum L.*, *Calotropis gigantea* fruit bunches and coconut fibre), bark (*Acacia planifrons*, *Cordia dichotoma* and *Grewia tilifolia*) and leaf (*Agava americana*, *Saharan aloe vera*, *Perotis indica* and *Artisdita hystrix*) [3]. They are widely available, cost-effective, low density, non-hazardous, renewable, sustainable and recyclable, providing good acoustic insulation and thermal properties, easy processing, and non-abrasiveness as reinforcing materials [4]. This making natural fibers is environmentally valuable because of its biodegradable nature [5].

Corn stalk fiber is one agriculture waste that also getting an attention as natural fiber by researcher nowadays. However, they have low compatibility between other matrices. This happen because their main chemical constituents are cellulose, hemicellulose and lignin, and these fibers also contains other small components such as resin, fat and pectin [6]. It is well documented that a weakness of natural fiber is their poor compatibility with composite matrix due to their hydrophilic lignocellulosic



molecules and low thermal stability [7]. Therefore, the modification should be taken to make sure that the natural fiber can be used and comparable with synthetic fiber.

There are many alternative ways that can be apply for modification physically or chemically to remove their natural hydrophilic properties and improve their mechanical properties. The several surface modifications technique of natural fibres that already been used whole world such as isocyanate treatment, acrylation, latex coating, permanganate treatment, acetylation, silane treatment and peroxide treatment with various coupling agents and others, have achieved various levels of success in improving fibre strength, fibre fitness and fibre-matrix adhesion in natural fibre composites [8]. However some of them are not effective to apply due they need advance technology and expensive.

In this research study, the modification use to improve surface and mechanical properties of corn stalk (Stalk pith section illustrate in figure 1) as natural fiber is by using chemical treatment. This technique is the most popular methods and widely use among researcher which the process for this treatment is by immersing natural fiber into treatment medium for specific concentration and time [9]–[12].

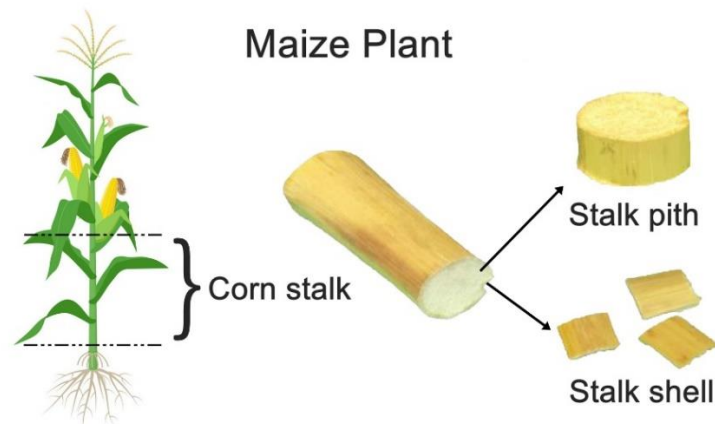


Figure 1. Stalk pith from corn stalk fiber [13]

2. Experiment Detail

2.1. Materials and methods

Corn stalk fiber at pith section that randomly collected from local farm have been used as natural fiber to modification by using chemical treatment. There are six chemical treatment that been classified as alkaline, acidic and natural medium follows in Table 2.1.

Table 2.1. Chemical treatment medium with their set up.

Classification of medium	Chemical used	Concentration
Acidic	Sulfuric acid, H_2SO_4	8 vol.% by dissolved in distilled water
	Nitric acid, HNO_3	
Alkaline	Sodium hydroxide, NaOH	
	Potassium hydroxide, KOH	
Neutral	Acetic acid (Vinegar), CH_3COOH	100% artificial vinegar
	Sodium bicarbonate, $NaHCO_3$	Dissolved in distilled water with 1:2 ratio

2.2. Chemical Treatments

The modification of corn stalk as natural fiber for this research study is by using chemical treatment. This technique is the most popular methods among researcher to modify the physical and chemical of

natural fiber. The process for this treatment is by immersing corn stalk fiber into treatment medium for 6 hours as shown in Figure 2.

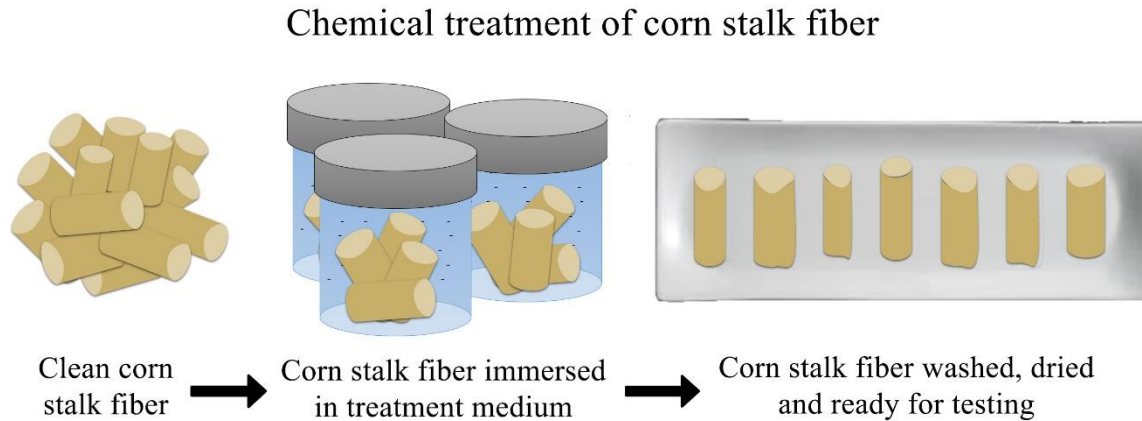


Figure 2. The schematic of chemical treatment process on corn stalk fiber

2.3 Surface Morphology

The surface morphological of corn stalk fiber was observed by using scanning electron microscope (SEM). The signals that derive from electron-sample interactions reveal information about the sample including external morphology, and fiber orientation of natural fiber or corn stalk [14]. The morphology study was performed using SEM, JEOL JSM-6460 LA and the activation voltage varied 10kV with magnification 100x. To provide an excellent image, the corn stalk fiber has been coated with platinum by using vacuum evaporation.

2.4 Absorption Ability Testing

Approximately the swelling test who also known as water absorption test for measure absorption ability of corn stalk. This testing was used as indicated by ASTM D570-98 (2018). Before start the testing, the corn stalk fiber was dried by using vacuum oven to remove all the moisture content that maybe affected by the environment. Then, measure and record the initial weight of corn stalk fiber by using electronic balance. The corn stalk fiber then were immersed into distilled water at room temperature for 24 hours. Reweighting the samples every day until 30 days. The percentage of water absorption calculated by using equation 1 [15]:

$$\text{Water Absorption (\%)} = \frac{W_2 - W_1}{W_2} \times 100\% \quad (1)$$

Where, W_1 refer to the initial weight of corn stalk fiber and W_2 refer to the final weight of corn stalk fiber

3. Result and Discussion

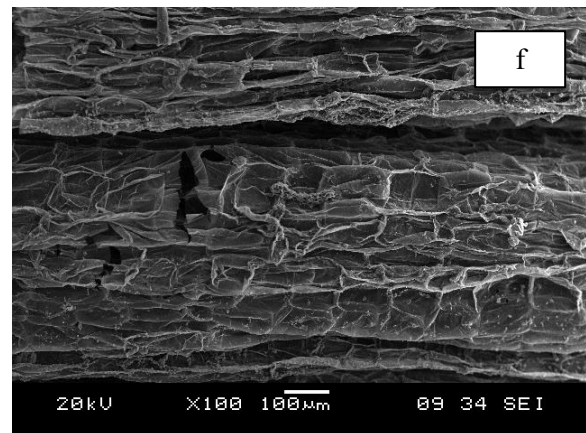
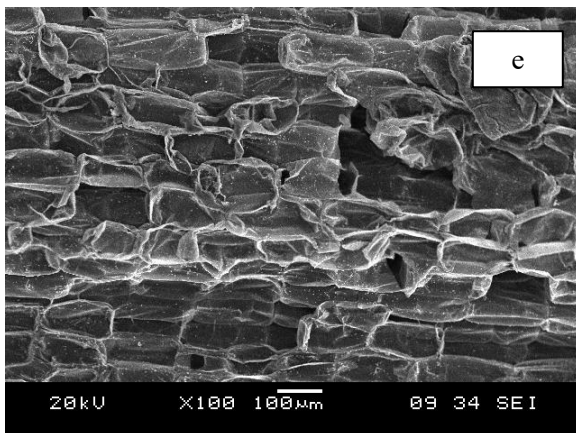
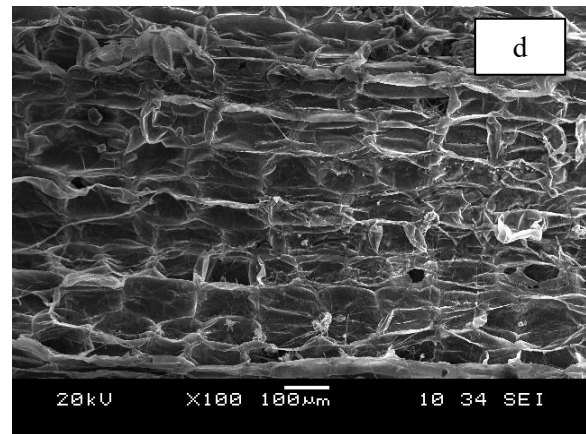
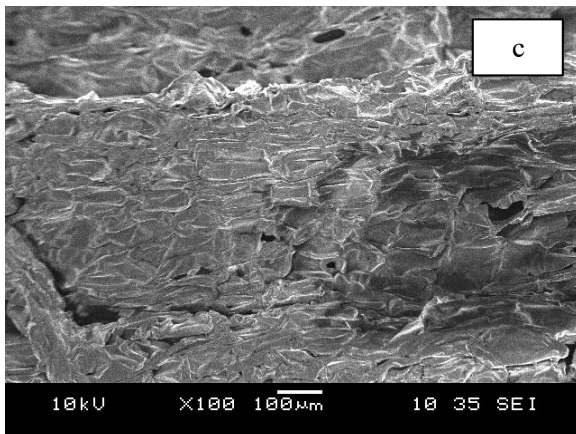
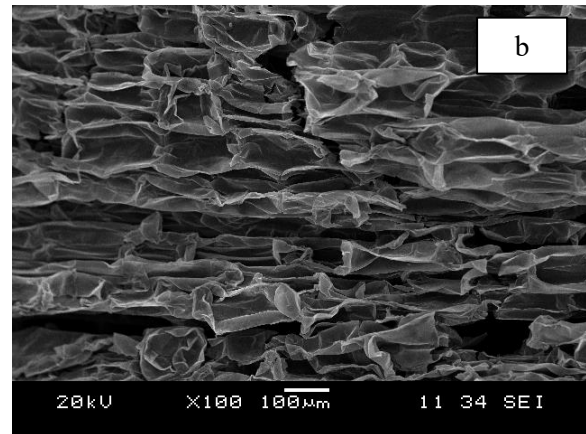
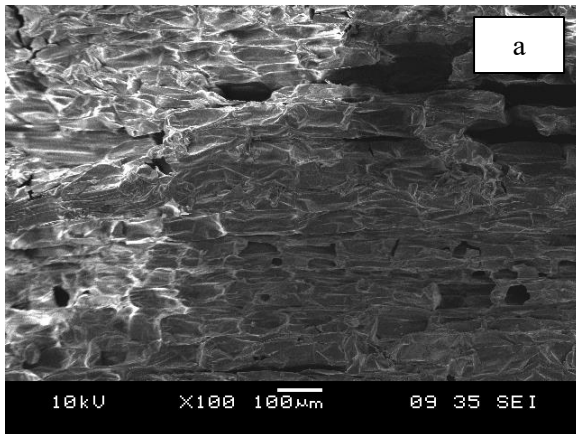
The result that presented in this paper are to differentiate the effect of chemical treatment on surface morphology and water absorption for untreated and treated corn stalk fiber.

3.1 Surface Morphological

The morphological of corn stalk fiber was illustrate through scanning electron microscopy with 100x magnificant as shown in Figure 3 (a-g). From the result, there were significant differences on surface morphology for both untreated and treated corn stalk fiber. As expected, untreated corn stalk fiber from Figure 3(a) exhibits the smooth surface compared with treated. This happen due to the presence of surface impurities such as wax, pectin, and greases that were covering the fiber [11]. Latip (2019) from their research also found that the untreated fiber relatively had a smooth surface that was covered

with a layer of substances consist of wax, lignin and hemicellulose which prevent the rupture activity to the fiber [16]. This will affected to their mechanical performance when they become as a composite. These is because the layers formed weak interfacial bonding between the fiber and the matrix [8].

The SEM image show some wrinkles and roughness from treated corn stalk fiber surface. This result was prove that the chemical treatment may use to improve the surface morphological of corn talk fiber by removing wax, pectin and other impurities. The wrinkles and roughness of corn stalk fiber was depend on the treatment condition [17].



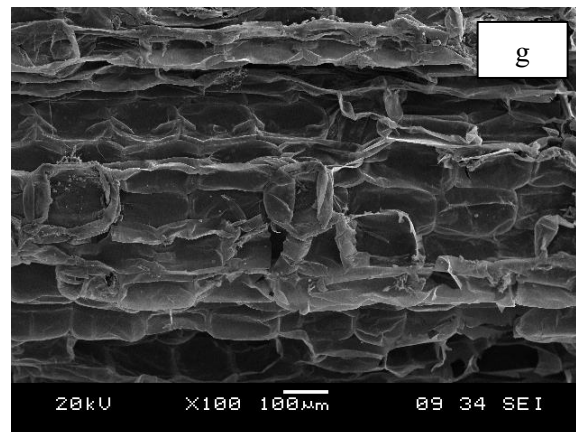


Figure 3. SEM micrograph of corn stalk fiber (a) Untreated, (b) KOH, (c) NaOH, (d) NaHCO₃, (e) H₂SO₄, (f) HNO₃ and (g) CH₃COOH

3.2. Absorption Ability Testing

The absorption ability of corn stalk fiber was elaborated by using swelling test which gives different result on water absorption percentage after 30 days. From Figure 4, the untreated corn stalk fiber shows the highest percentage of water absorption after 30 days with 97.92%. This result was proved that the natural fiber which rich with hydroxyl group especially from hemicellulose makes them become excellent hydrophilic materials. This evident also supported with other researcher which Lahouioui (2019) in their research also found that the untreated natural fiber show higher moisture absorption capacity caused by amount hydroxyl groups on the fiber [18]. However, from this research we emphasize that, the natural fiber has low hydrophilic properties which effectively remove the hemicellulose that may attributed to lower interfacial interactions between fibers and polymer matrix for next study.

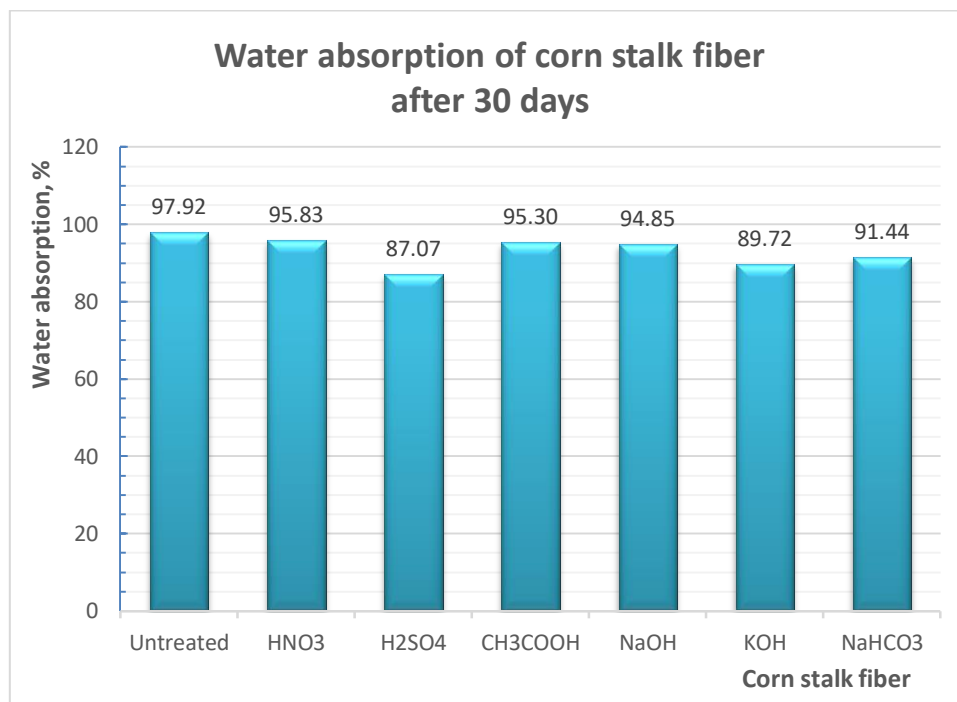


Figure 4. Water absorption percentage of corn stalk fiber

All treated corn stalk fiber show low water absorption percentage after 30 days compared to untreated corn stalk fiber. This result indicates that the chemical treatment was able to modified corn stalk fiber become more hydrophobic by removing chemical component that like the water especially hemicellulose. There are many researcher that also success in changing natural hydrophilic fiber to be more hydrophobic [19]–[22]. The corn stalk fiber treated with H_2SO_4 shows the lowest percentage of water absorption with 87.07%. Theoretically, the acid treatment promotes rupture in hemicellulose fibers, generating other sugars, such as xylose and arabinose cause less composition hemicellulose on the natural fiber [23]. This making the H_2SO_4 -treated corn stalk fiber which undergoes acidic treatment can be classified as the best result to form fiber with hydrophobic properties compared to others.

4. Conclusion

Based on this investigation may be concluded that the changes of surface morphology and water absorption abilities of corn stalk fiber can influence by the chemical treatment either from acidic or alkaline medium. The surface morphological of untreated corn stalk fiber exhibits the smooth surface due to presence of surface impurities like lignin and wax that were covering the fiber. However, the surface morphology of treated corn stalk fiber show some wrinkles and roughness because the chemical treatment from alkaline, acidic and natural medium was successfully the unnecessarily element that coating their surface. For the absorption ability, the highest percentage of water absorption is the untreated corn stalk fiber with 97.92% while the lowest percentage of water absorption is the H_2SO_4 -treated corn stalk fiber with 87.07% due to eliminate open hydroxyl group that tend to bond with water molecule.

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