Ju-ti : Jurnal Teknik Indonesia
ISSN : 2964-0490 (online)
Vol. 4, No. 2, 2025, pp. 209-216
https://jurnal.seaninstitute.or.id/index.php/juti

Impact of Naoh Modification on the Cellulosic Content of *Anthracothorax Viridis* Mango Wood Fiber (AVMWF) for Component of Polymer Composite

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Article Info
Keywords:
Cellulose, Hemicellulose, Lignin, FTIR, Anthracothorax Viridis Mango wood fiber

ABSTRACT

his research investigated how alkali treatment affects the chemical composition of Anthracothorax Viridis mango wood fiber (AVMWF). The study, conducted on samples from Kinkiso in Taraba State, Nigeria, sought to understand how soaking AVMWF powder in various concentrations of NaOH for different durations would alter its cellulose, hemicellulose, and lignin content. The initial chemical composition of the untreated AVMWF was 38.75% cellulose, 29.89% hemicellulose, and 30.28% lignin. The study found that alkali treatment significantly altered these percentages. The most notable result was a dramatic increase in cellulose content to 70.45%. This was achieved after soaking the AVMWF in a 7.6% (w/v) NaOH solution for 3.2 hours. Under these same conditions, the hemicellulose and lignin content were significantly reduced to 17.91% and 10.64%, respectively. Fourier-transform infrared spectroscopy (FTIR) analysis confirmed the chemical changes. The FTIR spectrum showed that the treated and untreated AVMWF had variant functional groups, specifically confirming changes in the hydroxyl (OH), carboxyl (COOH), carbon-hydrogen (C-H), and carbonyl (C=O) bonds. These spectroscopic results support the conclusion that the NaOH treatment successfully modified the fiber's chemical structure. The findings demonstrate that treating AVMWF with NaOH effectively increases its cellulose content while reducing its hemicellulose and lignin. Because of its new properties, which are similar to other natural fibers used in manufacturing, the study recommends that AVMWF be explored for its potential use in composite material production.

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INTRODUCTION

Natural fibers sourced from wood have been widely utilized in the manufacturing of various industrial products, including cardboard, paper, automobiles, and applications such as boats, mobile phone cases, laptop cases, and airplane components (Naidu et al., 2017; Raghuveer et al., 2016). This is due to their stiffness, thermal insulation properties, and renewability when compared to inorganic materials used in industrial products (Government et al., 2020(a); Muryanto et al., 2015).

The primary component of plant fiber is cellulose, derived from agricultural materials. Thare are other influential constituents which retard conjunction of fiber with other materials due to some gummy or gelly components(Government et al.,2019; Government et al.,2020; Government et al., 2025). This are called hemicellose, lignin and minutes contents which are eliminited after the fiber pretreatment. To cut long story short, cellulose, is biggest constituent followed by hemicelluloses and lignin (Government et al.,2020(a,b); Gupta et al., 2015; Sari et al., 2017; Zakikhani et al., 2014; Ahmadi et al., 2016; Brinchi et al., 2013; Ardanuv et al., 2015). For the fiber to be effective for productive commercialization process, it has be properly modifies to boost the cellulosic content while reducing the less attractive for mass production of its utilization(Government et al.,2019; Government et al.,2020; Government et al., 2025). Simple method of doing this is pre-treatment. This process not only swells the cellulose content but minimizes the redundant constituents from the fiber (Oushabi et al.,2017: Palamae et al.,2017: Shuhaida and Soh, 2016: Barlianti, et al., 2015; Government et al., 2019; Government et al.,2020; Okeke et al., 2023).

Some of the treatment media that aids fiber improvement with respect to cellulose contents are alkalization, acetylating, bleaching, silane treatment, neutralization, etc. But the method that is commonly utilized is alkalization (Oushabi et al.,2017: Palamae et al.,2017: Shuhaida and Soh, 2016: Barlianti, et al., 2015; Government et al., 2019; Government et al.,2020; Okeke et al., 2023). This procedure introduces the immersion of cellulosic material in alkaline aqueous medium at a short period of time, then rinse severally until the fiber results to ph of 7(Oushabi et al.,2017: Palamae et al.,2017: Shuhaida and Soh, 2016: Barlianti, et al., 2015; Government et al., 2019; Government et al.,2020; Okeke et al., 2023; Government et al., 2025). Some of the active agents that has be essentially utilized for this process are $Ca(OH)_2$, NaOH, KOH, $Mg(OH)_2$, etc. This modification enhances the sticking ability of the fiber, making to have more bonding strength when it comes in connection of its substrates (Agu et 2014; Government et al., 2019; Government et al.,2020; Okeke et al., 2023; Government et al., 2025).

Also the accumulated percentage gained by agro-fiber determines its utilization for fiber-polymer composite, for tissue paper, exercise book, for car parts, electronics component, or for car bumper. Generally, if the lignocelluloses yield has enlarge cellulosic's components can be used to fridge components, car parts, lap top parts, door panel, dashboard of a car and other components which required too much impact and strength(Agu et 2014; Government et al., 2019; Government et al.,2020; Okeke et al., 2023; Government et al., 2025). But lower strength fiber. That is, fiber with lower strength that has smaller value of cellulose components can be applied paper, toilets, tissue etc. (Agu et 2014; Government et al., 2019; Government et al.,2020; Government et al., 2025).

This research focuses on evaluating a new type of AVMWF and explores its potential for industrial use. There is a growing trend to substitute natural fibers with synthetic alternatives due to their beneficial properties, including low weight, stiffness, thermal insulation, and biodegradability. Although these materials have been employed in composite manufacturing, their high cost poses a challenge. Consequently, it is essential to utilize affordable materials derived from natural sources, such as plants, to lower the expenses associated with inorganic materials in composite production (Government et al.,2019; Government et al.,2020; Government and Okeke, 2023; Government et al., 2025).

Research has indicated that different types of reagents can be used to enhance the cellulose content in various fibers, including pinewood (Chen et al., 2014), rice straw (Shuhaida and Soh, 2016), flask fiber (Lazic et al., 2017), and century fiber. (Reddy et al., 2013), sugarcane derivatives (Ahmadi et al., 2016), discarded betel nut husk fiber (Sari et al., 2017), oil palm empty fruit bunch (Palamae et al., 2017; Muryanto et al., 2015), and rice straw (Suryanto et al., 2013). This study aim at examining compositional constituent of novel AVMWF, the effect of NaOH pretreatment variables on AVMWF and characterization of the AVMWF using FTIR for its recommendation for polymer composite production.

MATERIALS AND METHODS

Methodology

Material collection

The sample AVMWF was collected from Kinkiso Area of Wukari Local Government Area of Taraba State. The MWF was washed with distilled water and sun dried for 8 days at 6 hr. It was later crushed and sieved using 60 mesh sieve size. The AVMWF fine grain was then stored in a sealed container at room temperature.

Sample Pre-treatment

15 g of the crushed and sieved AVMWF was soaked in the NaOH solution with concentration of varied from 3.8 %w/v, 7.6 %w/v, and 11.4 %w/v. The solid part of the mango wood was washed at pH 7. The time of soaking was also varied from 1.6hr, 3.2hr and 4.8hr after which cellulose, hemicellulose and lignin contents were analyzed accordingly.

Chemical composition determination

Determination of cellulose and lignin content

The untreated and treated AVMWF was examined for its lignin and cellulose contents at different time and NaOH concentration using the Chesson method (Agu et al., 2014; Government et al., 2019; Government et al., 2020; Okeke et al., 2023) as detailed below; 1g of the dried sample of AVMWF was dissolved in a beaker containing 150ml of distilled water and was heated at 100°C for 1hour and weighed. The mixture (the dried MWF in the beaker containing 150ml of distil water) was dried filtered and weighed until the weight is stable. The residue was mixed with 150ml 0f 0.5M sulfuric acid and heated at 100°C for 1hour. The mixture was filtered and weighed. The residue was mixed with 10ml of 72%w/v sulfuric acid at room temperature for 4hours and then heated for 1hour and weighed. The residue was heated until it became ash and weighed. The cellulose and lignin contents of MWF were calculated as presented in equations 1 and 2, respectively.

$$cellulose\ content\ (\%) = \frac{(C-D)}{A} \times 100 \qquad (1)$$

$$lignin\ content\ (\%) = \frac{(D-E)}{A} \times 100 \qquad (2)$$

Determination of hemicellulose content

2g of the MWF residue was measured in a beaker and 10ml NaOH was added. The residue was agitated at 300rpm using an orbital shaker for thorough mixing with the NaOH. The NaOH was injected periodically to the mixture at a temperature of 20°C. About 33ml of distill water was added in the beaker and kept for 1hour. The residue was weighed (A). the residue was later transferred to a cubicle, washed with 100ml of NaOH, 200ml of distill water and 15ml of acetic acid. The cubicle with the residue was dried and weighed (B) the hemicellulose content of AVMWF was calculated using equation 3

$$Hemicellulose\ content\ (\%) = \frac{weight\ of\ residue\ (A) - weight\ of\ residue\ in\ cubicle\ (B)}{weight\ of\ residue\ (A)}$$

FTIR analysis

The FTIR for both crude and treated AVMWF was evaluated by the application of SHIMADU 8400s model spectrophotometer. The machine was equipped with TGS detector while the frequency was kept constant at 0.1cm^{-1}. The spectrum pattern was recorded in the transmission mode with a resolution of 4cm^{-1} at an interval of 3500 to 800cm^{-1}.

RESULTS

Table 1 depicts the chemical composition for the crude AVMWF. The cellulose content of the for raw AVMWF was 38.75%. The cellulose content from AVMWF was inferior than that of Kenaf, which ranged from 45% to 57% (Agu et al., 2014; Government et al., 2019; Government et al., 2020; Okeke et al., 2023). The hemicellulose content of AVMWF displayed 29.89%. This value is greater than that of ramie fiber that yields 13% to 16% (Agu et al., 2014). The lignin content was also similar to that of bamboo fiber, which ranges from 21% to 31% (Agu et al., 2014), and it exceeds the lignin content found in sugarcane, which is between 24.35% and 26.30% (Dungani et al., 2016). For the AVMWF showing an attribute when compared by former natural fibers, it is recommended for use in composite production (Agu et al., 2014).

Table 1: Chemical composition for the AVMWF without pre-treatment

Wood Fiber	Cellulose (%)	Hemicellulose (%)	Lignin (%)
AVMWF	38.75	29.89	30.28

The effect of NaOH pre-treatment on the cellulose content of AVMWF was captioned in Figure 1. With a soaking time of 1.6 hours, the cellulose content of AVMWF amplified from 52.19 to 57.46% as the NaOH concentration rose from 0 to 11.6% w/v. A similar trend was seen at a soaking time of 3.2 hours, with cellulose content increasing from 64.56 to 67.19%. However, at a soaking time of 4.8 hours, the cellulose content decreased from 63.95 to 57.03%.

Additionally, at 3.2 hours of soaking, the cellulose content went up from 64.56 to 70.45% when the concentration increased from 3.8 to 7.6% w/v NaOH. It then dropped to 67.19% as the concentration rose from 7.6 to 11.6% w/v NaOH in the AVMWF absorption solution. This indicates that increasing the NaOH concentration during AVMWF immersion damages part of the cellulosic composition of the fiber (Oushabi et al., 2017; Palamae et al., 2017). Nevertheless, at a concentration of 7.6% w/v, the highest cellulose content was found at 3.2 hours, reaching 70.45%. This shows that any change in the NaOH concentration will significantly affect the cellulose content of MWF. (Government et al., 2020(a); (Government et al., 2020(b); Government et al., 2019; Oushabi et al., 2017; Shuhaida and Soh, 2016).

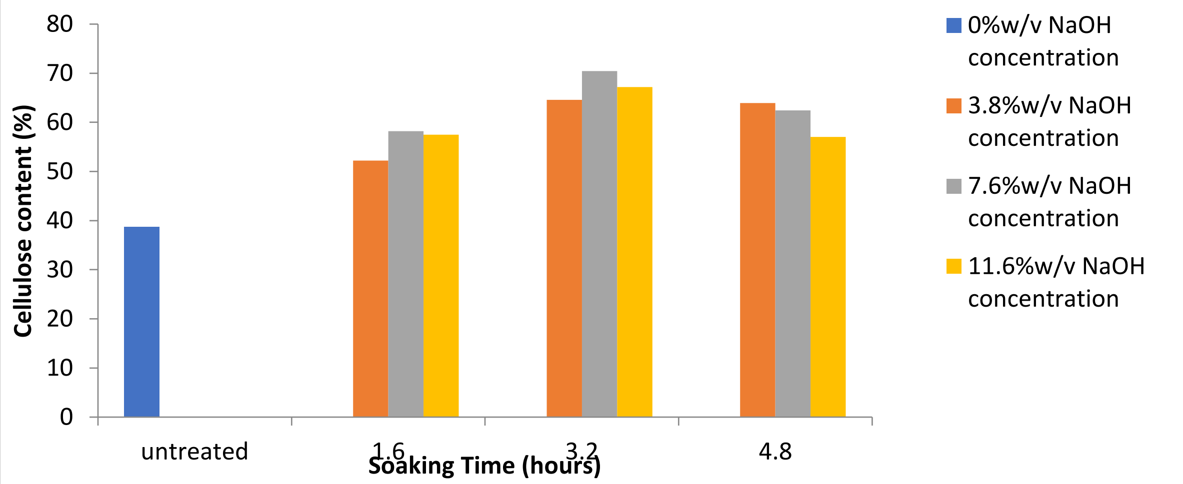

Figure 1: variation of NaOH modification on the cellulose content of AVMWF

Figure 2 shows how the treatment parameters affecedt the hemicellulose content of AVMWF. The results indicate that the highest hemicellulose content came from the raw AVMWF, which was 29.89%. As the concentration and soaking time increased, the hemicellulose content snags . At a soaking time of 1.6 hours, the hemicellulose content dropped from 22.26% to 22.02% as the NaOH concentration increased from 0% to 11.6% w/v. A similar trend occurred after 3.2 hours of soaking, where the hemicellulose content decreased from 20.5% to 17.94%. After 4.8 hours of soaking, the hemicellulose content rose from 19.64% to 21.9% as the NaOH concentration increased. Further increases in soaking time will also lead to an increase in the hemicellulose content of the AVMWF. This trend was also noted in previous studies (Government et al., 2020(a); Government et al., 2020(b); Government et al., 2019; Oushabi et al., 2017; Shuhaida and Soh, 2016).

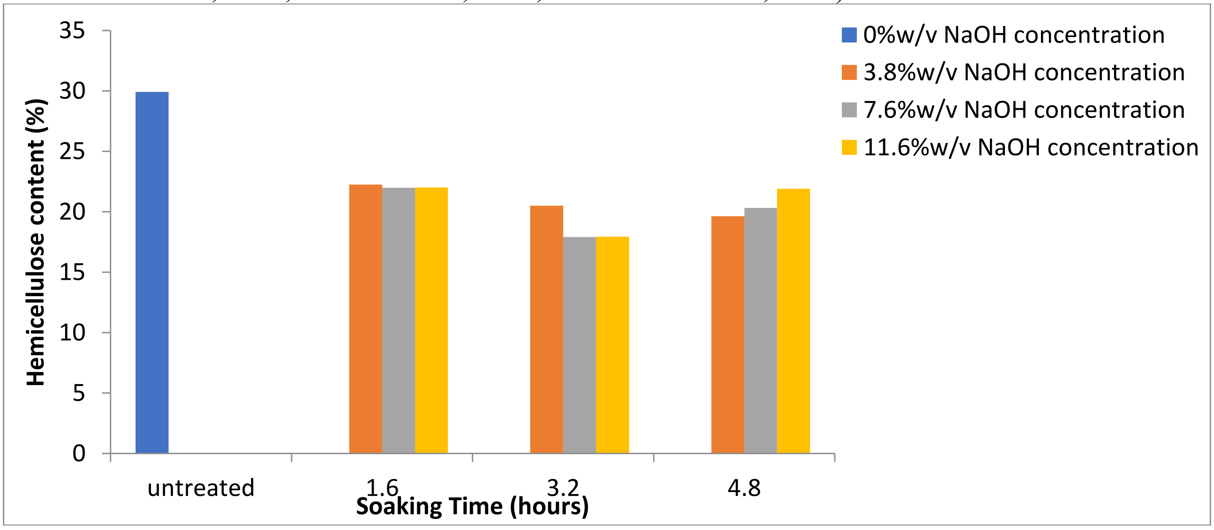

Figure 2: the influence off NaOH pretreatment on the hemicellulose content of AVMWF

Figure 3 shows how treatment parameters affect the lignin content of AVMWF. The results indicate that the amount of lignin removed from AVMWF decreased as the concentration of AVMWF augmented from 0 to 11.6 %w/v. The highest lignin content emerged for the crude AVMWF at 30.28 %. With a soaking time of 1.6 hours, the lignin content dropped from 23.39 to 20.52 % as the concentration of NaOH increased. A similar trend occurred with a soaking time of 3.2 hours, where the lignin content decreased from 14.94 to 14.87 %, showing a significant drop at a concentration of 7.6 %w/v NaOH, reaching 10.64 %. The lignin content rose from 17.94 to 21.16 % as the concentration of NaOH increased from 0 to 11.6 %w/v. The lignin components between the modified and pre-treated AVMWF fell from 30.28 to 10.64 % under these conditions. This aligns with earlier studies by other researchers (Government et al., 2020(a); Government et al., 2020(b); Government et al., 2019; Oushabi et al., 2017; Shuhaida and Soh, 2016).

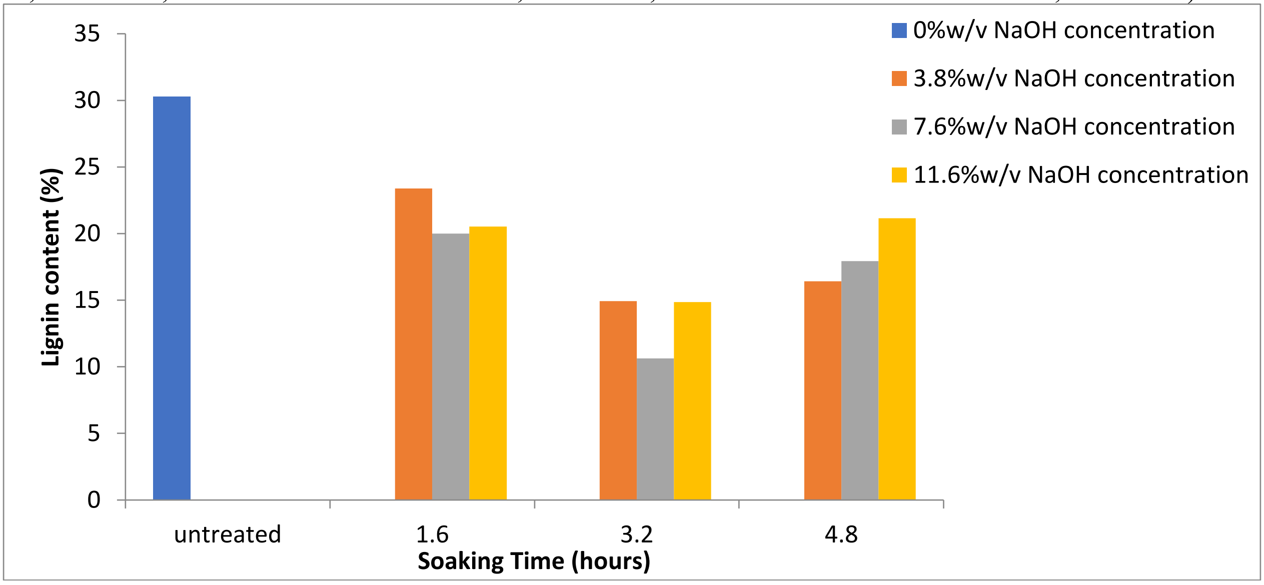

Figure 3: NaOH influence on the lignin content of AVMWF

The FTIR graphs of pure and chemically-treated AVMWF stated in Figure 4. The peaks at 3798.7 and 3642.3 cm^{-1} produced OH groups for the modified and the non-influence reagent of AVMWF, respectively. This difference resulted from the transformation in transmittance, which is influenced by NaOH on the AVMWF composition as captured in Figure 4.. The peak around 2433.1 cm^{-1} for the raw AVMWF noted the active -COOH- group. An aldehyde with 2 C-H signals was noticed at the apex of 2708.1 cm^{-1}at the graph in crude AVMWF. THE WAVE OF 1700.8 cm^{-1} of C=O group found for the raw AVMWF. The 800 cm^{-1}and 1500 cm^{-1} confirmed a C-C stretching vibration for the crude and modified AVMWF, respectively. From my inference in the FTIR SPECTRIA, there was transitional pushed from the crude to the chemically modified AVMWF upwards in the absorbance, wave number and missing of some wave numbers apex. This notification indicated the fact that NaOH pre-treatment downside the hemicelluloses, lignin and boosts cellulose components of AVMWF. This aligns with findings from former scholarly works (Ikramullah et al., 2019; Oushabi et al., 2017).

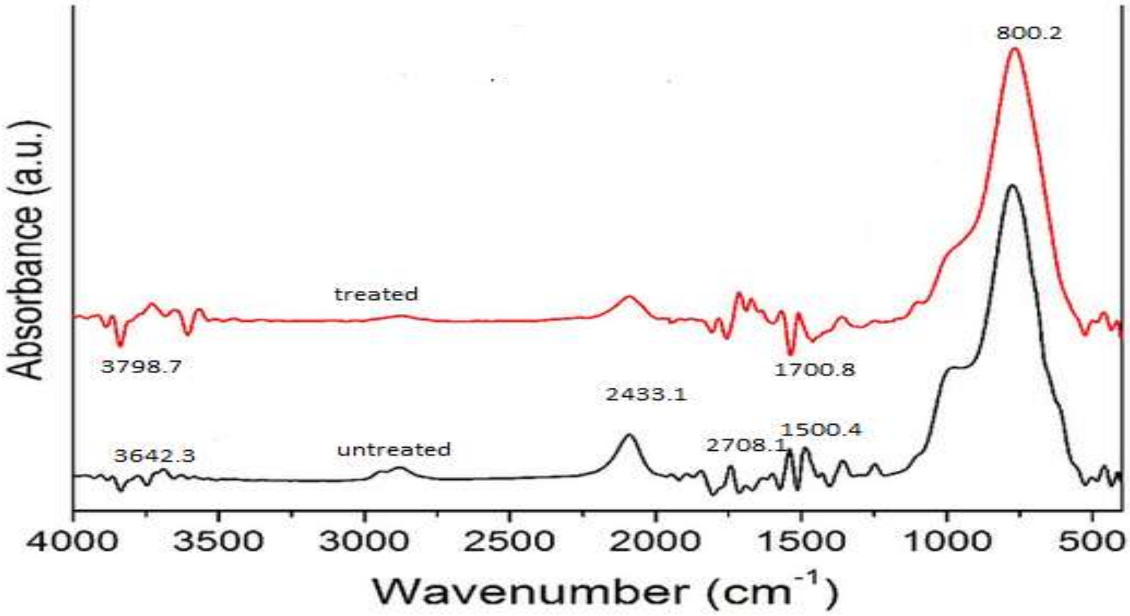

Figure 4: FTIR Spectria of the Treated and Untreated AVMWF

CONCLUSION

Natural fibers have received much attention due to their application in composites. Though they need to be modified to increase potentials to cut the use of synthetic fibers on the industry. Alkaline modification of the agro-based-plant under study affected the chemical composition of the AVMWF. The cellulose content of the AVMWF was superior and reduction in its hemicellulose and lignin content after reagent modification. The preeminent cellulose content was captured at elevated concentrations and minimal soaking time. FTIR examination inveterate this enhancement on the cellulosic component as the structural adjustment of the AVMWF was changed after the chemical characterization for minimization of unwanted incompatible constituent of AVMWF. From the results obtained indicates that the novel avmwf show that it is fiber that be utlized in polymer composite industry.

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