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Study on the Effect of Sodium Hydroxide Treatment on Surface Morphology and Tensile Properties of Oil Palm Empty Fruit Bunch

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Abstract: EFB fibre and cement combinations have been reported to have compatibility concerns since the fibres contain residual oil, sugar, lignin, hemicellulose and cellulose that prevent cement setting and hydration. Aside from that, the physical and mechanical properties of EFB are reported to be influenced by the fibre shape. As a result, this study was conducted to see how sodium hydroxide treatment affected the surface morphology and tensile strength of oil palm empty fruit bunches. The fibre were treated with sodium hydroxide (NaOH) at different concentration levels (0, 1, 2, 3, 4 and 5%). Alkaline treatment with sodium hydroxide is used in compatibility tests (NaOH) where to identified the physical properties for the fibre with different concentration of NaOH. This research finding found out that the higher the concentration, it will reduce the compatibility concerns which include the residual oil, sugar, lignin, hemicellulose and cellulose. The physical properties from the scanning electron microscope (SEM) eliminated gradually until 5% of silica bodies, lignin, hemicellulose and cellulose. Where the finding of mechanical properties with tensile test using different concentration show that the optimum value where on 4% of sodium hydroxide (NaOH). After going through compatibility enhancement procedures, the results from the study indicated that the concentration levels of NaOH had influenced the fibre properties.

Keywords: Empty Fruit Bunch, Sodium Hydroxide, Physical Properties, Mechanical Properties.

1. Introduction

Natural fibres such as oil palm fibre from empty fruit bunches (EFB), have been increasingly popular as composite reinforcement in recent years. Palm oil is a commodity that is quickly developing in Southeast Asia, particularly in Indonesia and Malaysia. About 85% to 90% of the world's palm oil is produced in these two countries. Palm oil commodities are one of the country's foreign exchange

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earners and play an important part in the Indonesian economy. The oil palm industry employed up to 57 % of the population in Riau province and 10 % to 50 % of the people in eleven other Indonesian regions in 2007. Science and technology have progressed to the point where new polymers with superior performance at a reduced cost are needed [1].

Currently growing in this period with the development of functional and efficient empty fruit bunches that can be used in the buildings construction and civil engineering structures. Biodegradability, low energy consumption, low density, no carbon emissions, non-toxic, acceptable specific strength qualities, etc are all advantages of the EFB [2]. Meanwhile, empty fruit bunches (EFB) have a variety of disadvantages, including poor moisture resistance, durability, fiber-to-matrix compatibility, and resistance. As a result, the focus of this study will be focus on EFB, which is a type of biomass produced during the palm oil manufacturing process. As the amount of EFB disposed of as garbage has increased, it is now being used as fuel [16]. The moisture level of EFB is often high, which decreases the combustion temperature and diminishes energy efficiency [2].

In order to reduce this, pre-treatment are necessary to be conducted. The three components of EFB fibre are lignin, hemicellulose, and cellulose, as well as solubility such as sugar [3]. The fundamental impediment to the production of EFB fibre cement composites is chemical incompatibility between fibre and cement, which prevents the cement from setting and hardening. The influence of several chemicals such as sodium hydroxide (NaOH), hydrocholic acid (HCl), Nitric acid (HNO_3), ethylenediamine (EDA), and ethylenediaminetetraacetic acid (EDTA) on chemically untreated OPEFB fibre boosted cellulase production. It has been looked into, and some reactions have been studied. The cellulose content was greatly enhanced while the lignin content was significantly reduced after treatment with these compounds. The largest cellulase production was obtained by fermenting oil plam empty fruit bunch (OPEFB) fibre treated with HNO_3, which was due to its high cellulose content. When autoclaved, chemically treated OPEFB fibre was employed, cellulase production rose even more. C. globosum produced cellulase with a high concentration of glucosidase. Natural fibre pre-treatment and cement accelerator have shown to be the most successful strategy employed by researchers thus far. Chemical treatment with sodium hydroxide (NaOH) is a common EFB fibre pre-treatment method utilised by other researchers is NaOH.

The main objective of this study is to investigate the effect of an empty fruit bunch (EFB) treated with various percentages of sodium hydroxide (NaOH) on surface morphology (SEM) and To compare the effects of different sodium hydroxide (NaOH) concentrations on the tensile characteristics of empty fruit bunch (EFB) fibre.

2. Properties of EFB Fibre

All natural fibres, either wood or non-wood are cellulosic in most circumstances. Two primary components of natural fibres are cellulose and lignin [4]. Environmental conditions during plant growth, as well as the extraction procedure utilised, influence the chemical structure of natural fibres, such as cellulose content, degree of polymerization, orientation, and crystalline. Figure 1 show the EFB fibre after shredding process.

Figure 1: EFB Fibres after shredding process

3. Materials and Methods

The materials and methods section, otherwise known as methodology, describes all the necessary information that is required to obtain the results of the study.

3.1 Materials

In this study, Oil Palm Fibre (OPF) has been used in which was comprised of empty fruit bunches (EFB), this factory is namely Pamol Kluang Palm Oil Mill. This factory is located at $8^{1/2}$ miles, Jalan Mersing 86000 Kluang Johor industrial area. The fibres were sun dried for at least a day and then use canvas as a liner. Then shredding process where shredder to reduce dried oil palm EFB into shorter lengths of fibre. Lastly continue on hammer mill machine to reduce the shorter fibre into fine fibre. EFB fibre was then treated with 1%,2%,3%,4% and 5% of NaOH for pre-treatment.

3.2 Testing for EFB Fibre

Testing for EFB fibre includes EFB fibre tensile testing and scanning electron microscope (SEM).

3.3 EFB fibre tensile strength

For the assessment of tensile strength, this test technique involves the preparation, mounting, and testing of single fibres (obtained from an EFB fibre bundle). It also aims to look into the workability of tensile strength of untreated EFB fibre treated with various NaOH concentrations (1%, 2%, 3%, 4% and 5%). Figure 2 shows the EFB fibre preparation for tensile testing, Figure 3 show the sample preparation and Figure 4 show the tensile testing procedure for EFB Fibre.

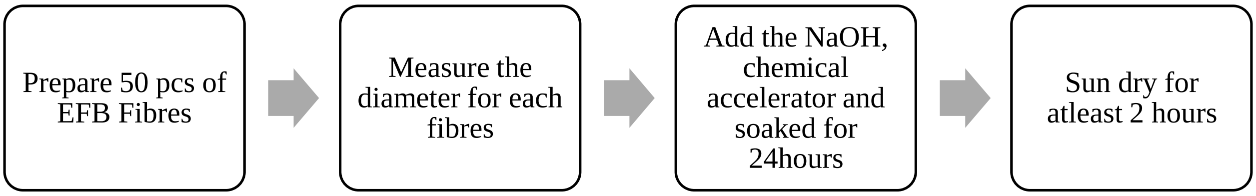

Figure 2: EFB fibre preparation for tensile testing

Figure 3: The sample preparation

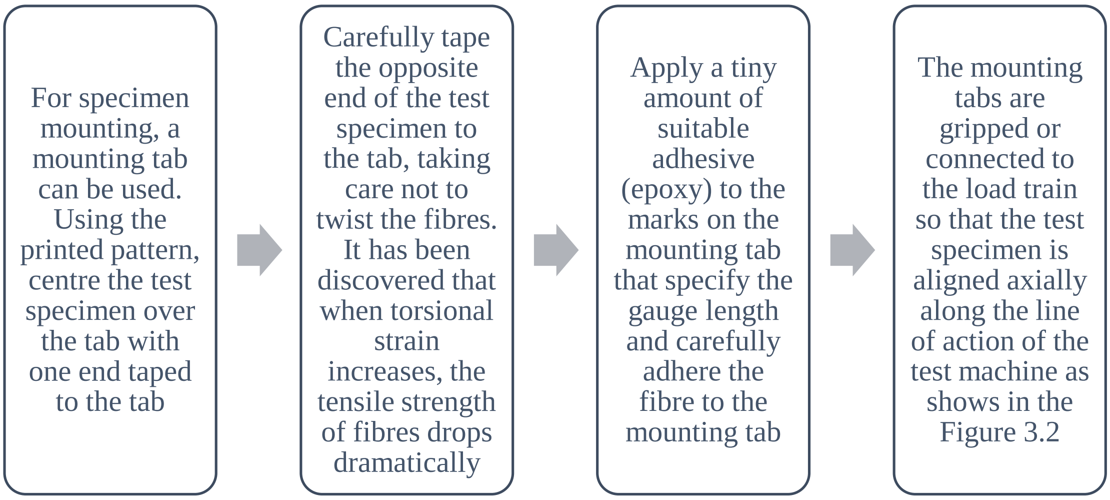

Figure 4: Tensile testing procedure for EFB Fibre

3.4 Surface morphology analyses

Scanning Electron Microscopy (SEM) images of EFB fibre samples were studied to investigate the interfacial compatibility of the EFB fibre. The sample specimens were examined to observe the morphology of the composite surface. The SEM analysis was done for EFB fibre to investigate the interaction between the untreated EFB fibre and the treated EFB fibre using difference concentration which is untreated EFB 0%, and treated EFB from 1%, 2%, 3%, 4% and 5%. The raw fibres are washed under running water in order to eliminate any unwanted particles or any fungus retained on the fibre. In this study, sodium hydroxide (NAoH) is being used in the pre-treatment method with different concentrations. The chemical treatment is a process where the fibre is soaked with sodium hydroxide (NaOH) for 24 hours [5]. to remove inhibitory substances and oil residues in the fibre that could affect the hydration of cement. After being soaked in the NaOH solution, the fibres were washed several times with tap water to remove excess NaOH from the fibre surface until the water no longer shows any alkalinity checked by using PH meter tester. The fibre was dried to maintain 10-15% of fibre moisture to prevent fungal attacks [6].

3.5 Equation

Tensile strength	Scanning Electron Analyses
Tensile strength, T=F/A Where: T = Tensile strength, Pa (or psi) F = Force to failure, N (or 1 tb) A = Average filament area, m^2 (or in^2)	Mn = ((Ww -Wd) / Ww) x 100 Where: Mn = moisture content (%) Ww = wet weight of EFB fibre Wd = weight of the EFB fibre after drying

4. Results and Discussion

4.1 EFB Mechanical Performance Based on Different Percentage of NaOH Treatment

According to the different percentages of Sodium Hydroxide (NaOH) pre-treatment, the mechanical properties of EFB were interpreted and discussed in terms of the tensile strength (T) performance. The tensile strength was determined by increasing of concentration after the fibre soaked for 24 hours. This test was carried out as specified by the ASTM standard (ASTM D3379).

As in Figure 5, in comparison to the untreated fibres, the fibre treatment appeared to boost the tensile strength marginally. The results also showed that increasing the concentration of NaOH enhanced the tensile strength of EFB fibres significantly. These findings, however, contradict those [7] who claimed that alkali treatment reduces tensile strength due to damage induced by a chemical structural shift in which cellulose in the fibre partly converts from crystalline to amorphous cellulose.

Furthermore, alkali treatment lowers the strength of the fibre owing to cellulose chain breakdown [8]. On the other hand, the alkaline treatment for 4 % NaOH concentration resulted in increased tensile strength [9]. When the fibre is exposed to greater concentrations of NaOH which higher then 4% of the tensile strength falls owing to lignocellulose breakdown and fibre surface rupture. The elimination of lignin and hemicellulose boosted the tensile strength of EFB fibres substantially when they were treated with alkaline, according to the findings.

The findings are consistent with those who found that fibres treated with NaOH have better tensile strength, Young's modulus, and percentage of elongation than untreated fibres [10]. Alkali treatment, according to Mohanty et al. (2001), might depolymerise native cellulose and delignify the fibre excessively. This, in turn, can have a negative impact on fibre strength.

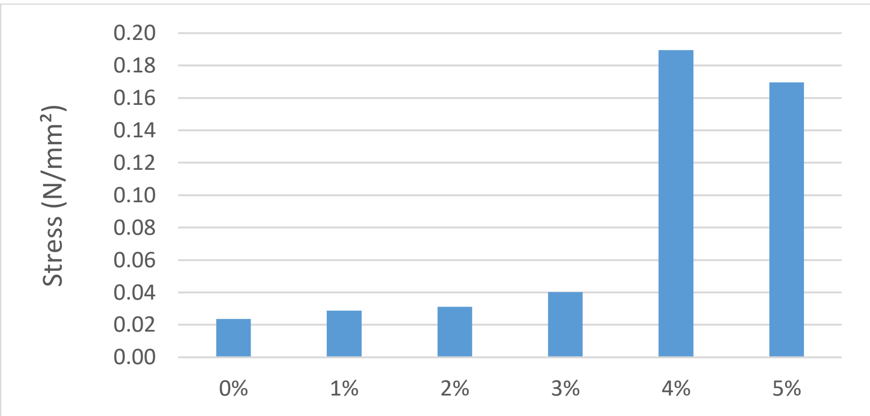

Figure 5: Tensile strength of Untreated fibre (0%) and fibre treated with 1%, 2%, 3%, 4% and 5% concentration of NaOH

4.2 EFB Physical Performance Based on Different Percentage of NaOH Treatment

According to the different percentages of Sodium Hydroxide (NaOH) pre-treatment, the physical properties of EFB were interpreted and discussed in terms of the scanning electron microscope (SEM) performance.

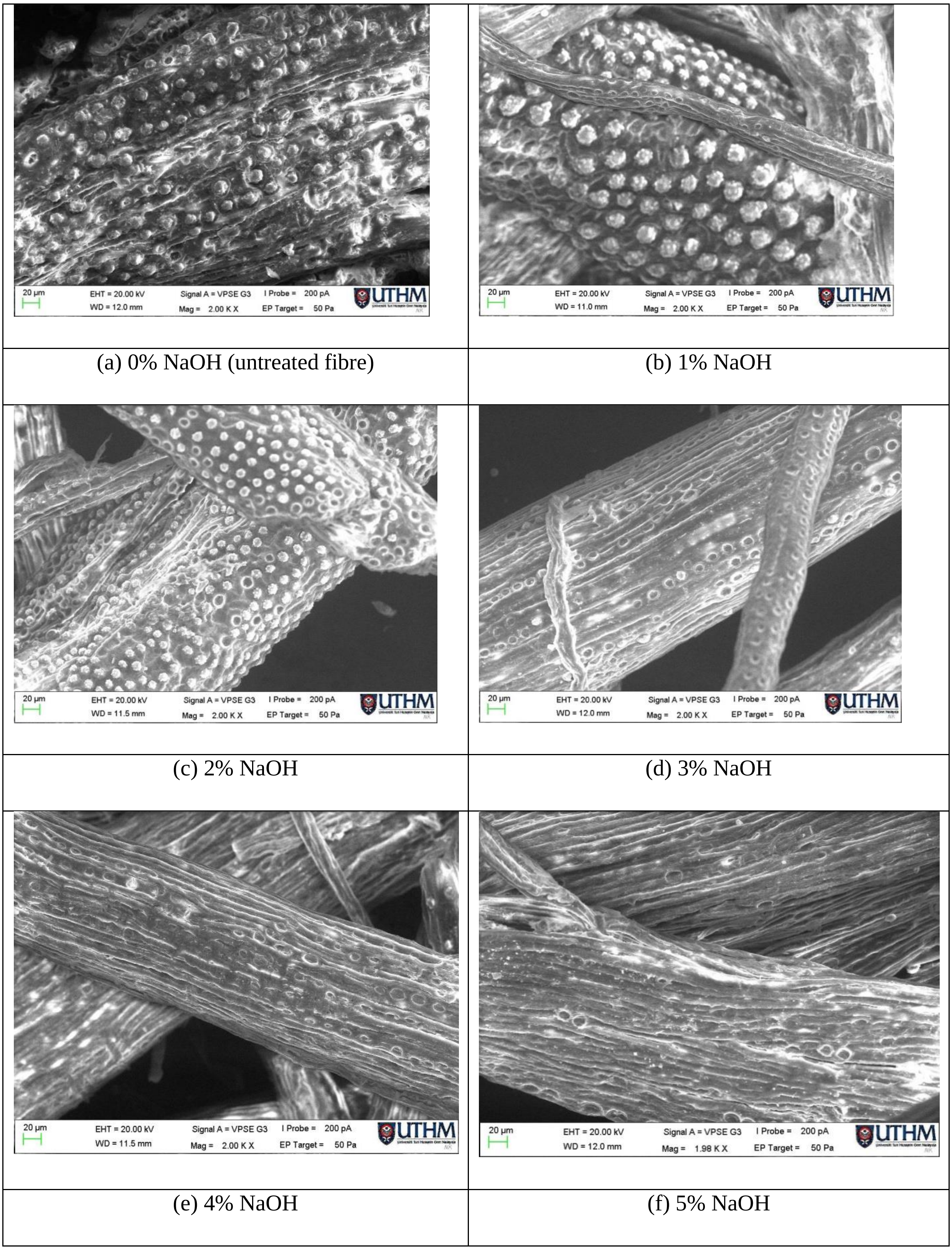

Figure 6: Electron micrographs images for EFB fibre specimens with different percentages of NaOH

The scanning electron microscope (SEM) was determined by increasing of concentration after the fibre where soaked for 24 hours. Figure 6 depicts the microstructure of EFB fibre specimens for both untreated and treated fibre. The presence of surface contaminants on the untreated EFB fibre surface is particularly visible, as shown in Figure 6 (a). As a result, it prevents the fibres from joining together. The inclusion of silica bodies, as indicated by [11][12], inhibits the crystallisation of silica bodies, influencing the compatibility of the combinations. Figure 5 shows the outcome of utilising fibre that has been treated with 1% NaOH (b). The interaction between treated and untreated EFB fibres appears to be superior. The microstructure, on the other hand, revealed a break between the threads and the silica bodies.

This effect can also be clearly observed in the electron micrograph images presented in Figure 6 (c). The EFB fibre surface showed a significant improvement than fibre which underwent 1% and 2% NaOH treatment and untreated fibre. The fibre was fully coated. The interaction between the EFB fibre treated with 3% and 4% NaOH was enhanced (Figure 6 (d) and (e)). This could be attributed to good adhesion in between 5% NaOH treated fibres. This could be attributed to the good adhesion between the treated fibre. As mentioned by [13] treated fibre in reinforced cement composites decreases fibre pull-out and increases matrix crystallinity. In line with the results by [14], fibre treated with 5% NaOH was found to enhance the properties of composite material.

However, due to the presence of silica bodies adhered to the fibre surface, the morphology study for further sodium hydroxide (NaOH) accelerators revealed inadequate interaction between the untreated and treated fibres. The fiber's surface was not smooth.

5. Conclusion

Based on the analysis and discussion of this study, it is found that the physical and mechanical properties of empty fruit bunch (EFB) and sodium hydroxide (NaOH) can be improve the silica bodies with some of mechanical treatment. The results of the investigation were very encouraging. The resulting physical properties indicated that the optimum performance can be obtained is 4% of sodium hydroxide (NaOH). Besides that, the treated fibre of 4% NaOH was found to enhance the properties of composite material. Next, the higher the concentration may remove some of silica bodies such as lignin, hemicellulose and cellulose. The fiber's surface was not smooth with further sodium hydroxide (NaOH) accelerators revealed inadequate interaction between the untreated and treated fibres. For the resulting mechanical properties indicated that the optimum performance can be obtained is 4% of sodium hydroxide (NaOH).The higher the concentration may affected the time and tensile strength.The untreated fibre show the gradually dropped rather that the treated fibre such as fibre with 4% and 5% of sodium hydroxide (NaOH).

In conclusion, this recycling strategy has two major advantages. To begin with, a possible new construction material can be created. The findings suggest that EFB fibre could be used as a non-load-bearing substitute material in non-load-bearing applications. Only when the mix is properly created and prepared to meet the requirements can this be done in conjunction with compatibility improvement methods. Second, given the massive amounts of OPEFB produced each year in Malaysia, recycling EFB fibre by incorporating it into construction development is a feasible and possibly substantial contribution to Malaysia's sustainable construction industry.

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