The Effect of Multiple Surface Treatments on Oil Palm Empty Fruit Bunch (OPEFB) Fibre Structure

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Abstract. The key objective of this work was to study the effect of multiple surface treatments on the oil palm empty fruit bunch (OPEFB) fibres. To achieve this purpose, the OPEFB fibres were treated with the sodium hydroxide (NaOH) (3%), silane (2%), a combination of NaOH (3%) and silane (2%) (NaOH+silane), and NaOH (3%) prior silane (2%) (NaOH-silane). The soaking time was standardized for 7 hours. The multiple treated and untreated fibres were subjected to single fibre test and scanning electron microscopy (SEM). The single fibre tests were performed according to ASTM D3822-07 standard using INSTRON Micro tester while microscopy was observed by using Scanning Electron Microscope (SEM) TM3000. The result shows that the treated fibres with 3% concentration of NaOH have achieved the maximum ultimate tensile stress of 82.04 MPa compared with other treatment and untreated fibre.

Keywords: Natural fibre reinforced composites; natural fibres; alkali treatment, silane treatment, cellulosic.

1. Introduction
Due to the light weight, high quality to weight proportion and the decomposition necessary in building and designing areas, natural fibre composite is a promising future composite material [1]. The oil palm empty fruit bunch (OPEFB) is one of the potential natural fibres to be explored [2]. Well known that Malaysia has the successful oil palm industry that contributes to the major national financial development [3]. Found that, as much as 90% of the aggregate biomass delivered into the wastes whereby its consist of OPEFB, trunks, kernel shells and oil palm fronds and part of that only 10% of it delivered as oil [4]. In real field, certain waste like kernel shells and fronds can be used as boiler organic fuel and food for livestock animals respectively. However, most of it likes OPEFB and trunks tend to dispose and the disposal process is always exposed to the pollution issue; OPEFB and trunks are mostly incinerated. Based on the observations, the OPEFB fibre waste can be changed into useful products by utilising fibre based (natural fibre) composite as opposed to blazing it. The cellulososes,
hemicelluloses and lignin are the three primary constituent structures of OPEFB. The modification of these constituents might result for a steady holding among matrix and fibre with increasing the mechanical properties of the composite. For this purpose, chemical surface treatment on fibre is the common approach for fibre constituent modification in order to achieve a good consolidation between fibre and matrix [5]-[9]. The common chemicals such as sodium hydroxide (NaOH), acetyl acid, and silane were used for surface treatments [10], [11]. In this paper, elastic properties; tensile, modulus of elasticity and morphological structure of the fibres are discussed.

2. Materials and methods
The United Oil Palm Industries, Nibong Tebal, Pulau Pinang had supplied the oil palm empty fruit bunch (OPEFB) fibres for this research. Following the water retting process, the fibres were manually extracted hair by hair. The water retting process took about a week to remove the residual oil and cleaned using distilled water. Next, the fibres dried under the sun to ensure the removal of its moisture content. The OPEFB fibres were then treated with NaOH (3%), silane (2%), a combination of NaOH (3%) and silane (2%) (NaOH+silane), and NaOH (3%) prior silane (2%) (NaOH-silane). Entire treatments were standardized for 7 hours of soaking time at room temperature and maintaining the liquor ratio 40:1 to remove the hemicelluloses and surface impurities of the fibre. Finally, the fibres were cleaned using distilled water and dried at room temperature. The measurement of the length, and diameter were taken as shown in Table 1. The measurements were performed prior to the tensile test.

| Type of treatment       | Average diameter (mm) | Fibre length (mm) |
|-------------------------|-----------------------|-------------------|
| Untreated               | 0.475 ± 0.012         | 60                |
| NaOH (3%)               | 0.375 ± 0.009         | 60                |
| Silane (2%)             | 0.449 ± 0.015         | 60                |
| NaOH (3%) + silane (2%) | 0.323 ± 0.012         | 60                |
| NaOH (3%) – silane (2%) | 0.358 ± 0.007         | 60                |

The single fibre tests were performed to determine the tensile strength of the fibre according to ASTM D3822-07 standard using INSTRON Micro universal testing machine with a load cell of 2kN. The fibre was mounted onto a tab-shaped piece of paper with the gauge length 40 mm. The dimensions of the multiple treated and untreated fibres were measured using digital microscope and weighed using an analytical balance device. The fibre's surface morphological were observed using Scanning Electron Microscope (SEM) TM3000.

3. Result and discussion
Figure 1 shows the stress-strain responses of untreated and multiple treated of OPEFB fibers. The NaOH (3%) treated fibers exhibits a higher ultimate tensile stress following NaOH (3%)+silane (2%), silane (2%), NaOH (3%)-silane (2%), and untreated for decreasing pattern. The treated fibers exhibit the higher tensile stress due to changes in the cellulose crystallinity. The change process involves the removal of weak amorphous of the fibers. The removal enables the fibril to rearrange them in a more compact manner, thus enhancing the tensile strength of the fiber [8].
A Figure 2 exhibits the clear view of the average tensile stress of fibres with 82.04 MPa is a higher value represents NaOH (3%) treatment followed by 61.47 MPa, 54.32 MPa, 42.1 MPa, and 39.99 MPa for NaOH (3%) +silane (2%), silane (2%), NaOH (3%)silane (2%), and untreated respectively. This indicates that the NaOH(3%) had increased exceeded 100 % from the untreated fibre.

The highest average Young’s Modulus of OPEFB fibres recorded is 1.05 GPa for silane (2%) while the lowest is 0.79 GPa for NaOH (3%)-silane (2%). Sighted these results in Figure 3, all the surface treatments improved the fibre elasticity compared with untreated except for the NaOH (3%) -
silane (2%). The NaOH (3%) - silane (2%) indicates a slight reduction in elasticity about 3.8%. Hence, the different modulus elasticity may result in the different strain to failure of specific fibre.

![Figure 3. Modulus of Young for untreated and multiple treated OPEFB fibres.](image)

The Scanning Electron Microscope (SEM) was used to learn about the surface morphology of the untreated and multiple treated OPEFB fibres and its exhibits in Figure 7. The untreated and NaOH (3%) - silane (2%) treated fibres depicts an almost similar physical condition whereby the impurities clearly existed on the fibres surface as shown in Figure 7(a), and (e). The NaOH (3%) and NaOH (3%) + silane (2%) were also depicted the similar physical condition which the rough surfaces existed as shown in Figure 7(b), and (d). Meanwhile, for silane (2%) in Figure 7(c), the surface was not very clean compared with others but it has fewer impurities and a rough surface existed. Due to fewer impurities and rough surface existed, the silane (2%) treated fibres registered as higher Young's Modulus.

![Figure 4. Surface morphologies for untreated and multiple treated of OPEFB fibres.](image)
4. Conclusions
The mechanical properties of the multiple treated and untreated OPEFB fibres were investigated in this paper. Found that, all treated OPEFB fibres shows the increasing of tensile strength compared with untreated fibres. The structure of the fibre also differences between the multiple treated and untreated fibre. The result shows that the NaOH (3%) treated fibre exhibited better tensile strength with 82.04 MPa compared with other treated and untreated. The surface observation through Scanning Electron Machine (SEM) shows the texture of the untreated and NaOH (3%)-silane (2%) fibres achieved the similar morphology with the impurities were significant while NaOH (3%) and NaOH (3%)+silane (2%) treated also have the similar condition with surface roughness existed. Finally, silane (2%) treated fibre shown different physical when no significant impurities and surface roughness existed. The study further supported the feasibility of utilising OPEFB fibres as reinforcing materials in polymer composites.

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