The Effect of Alkaline Treatments with Various Concentrations on Oil Palm Empty Fruit Bunch (OPEFB) Fibre Structure

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Abstract. The main goal of this work is to study the effect of different concentration level of alkaline solution for oil palm empty fruit bunch (OPEFB) fibre structure. As to achieve this objective, the OPEFB fibres were treated with 2 hours of soaking time with 3%, 5%, 7%, and 10% of sodium hydroxide (NaOH) concentration portion. The single test for treated and untreated fibers was then carried out according to the ASTM D3822-07 standard. Next, the surfaces of the fibres prior and after the treatment were observed with a scanning electron microscope (SEM) TM3000. The result shows that the 3% of the NaOH concentration exhibits better tensile strength compared to the other concentrations and untreated fiber.

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

1. Introduction

Recently, the utilising natural fibres as composite have expanded significantly in a couple of years. It is promising as future composite material due to the light weight, high quality to weight proportion and the decomposition necessary in building and designing areas [1]. One of the potential natural fibres to be explored is the oil palm empty fruit bunch (OPEFB) [2]. The oil palm trees can grow well in Malaysia atmosphere. It has extremely turned into the most critical rural product in Malaysia and has been most successful industry that contributes to the national financial development after petroleum [3]. However, only just 10% of the aggregate biomass delivered into oil and 90% of it delivered as wastes. The wastes consist of large amounts of lignocellulosic material, for example, OPEFB, trunks and oil palm fronds [4]. In order to dispose the waste, the process is always exposed to the pollution issue; OPEFB and trunks are mostly incinerated. Found that these agriculture wastes, particularly of OPEFB, can be changed into useful products by utilising fibre based (natural fibre) composite as opposed to blazing the OPEFB. The structure of OPEFB comprises of three primary constituents; celluloses, hemicellulose and lignin. The steady holding among matrix and fibre can increase the composites mechanical properties by modifying the constituents. Thus, to achieve a good consolidation between fibre and matrix, surface treatment on fibre is the common approach adopted via chemical treatments for fibre constituentôs modification purposes [5]-[9]. The sodium hydroxide (NaOH), acetyl acid, and silane were the common chemicals that used for surface treatments [10]. However, this research is focused on the effect of NaOH concentration of the OPEFB fibre. The elastic properties; tensile, modulus of elasticity and morphological structure of the fibres are discussed.

2. Materials and methods

The fibres that obtained from United Oil Palm Industries, Nibong Tebal, Penang were manually extracted prior continue to water retting process for a week. The fibre was then cleaned using distilled water and dried under the sun for removal of the moisture content. Next, the processed of OPEFB fibre was treated with 3%, 5%, 7% and 10% aqueous solutions of NaOH at room temperature for 2 hours, maintaining the liquor ratio 40:1 to remove the hemicelluloses and surface impurities of the fibre. Finally, the distilled water was used to clean the fibres before it dried at room temperature. The physical properties of the treated and untreated fibres are presented in Table 1.

Table 1. Physical properties of OPEFB fibres. (20 samples for each NaOH concentration)

NaOH concentration (%)	Average diameter (mm)	Standard deviation	Average length (mm)
3	0.34	0.05	70
5	0.27	0.04	70
7	0.29	0.04	70
10	0.31	0.05	70
Untreated	0.47	0.06	70

ASTMD3822-07 standard was used in single fibre testing to determine the tensile strength of the OPEFB fibres. The treated and untreated fibres were weighed and physically measured by using an analytical balance device, and microscopic. Meanwhile the surface of the fibres was observed using Scanning Electron Microscope (SEM) TM3000. The fibres were dried by using oven to the temperature of 60°C to 100°C about 30 minutes to an hour before proceeding with the test. The fibre was mounted onto a tab-shaped piece of paper with the gauge length is 70 mm. The INSTRON 5848 Micro universal testing machine with a load cell of 2kN were used to determine the tensile strengths of the treated and untreated fibres.

3. Result and discussion

The stressï strain responses for untreated and alkali-treated OPEFB fibres are shown in Figure 1. The treated fibres exhibit a higher ultimate tensile stress due change 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]. The result shows that the 3% of NaOH concentration have the highest ultimate tensile test. Following the 10%, 5%, 7% of the NaOH concentration, there is an increase in the tensile stress but a decrease in strain compared to untreated fibers.

As shown in Figure 2, the 3% treated fibres exhibit 111.8 MPa which is the highest tensile strength. The tensile strength initiates to decrease from 100.8 MPa, 68.4 MPa, 31.6 MPa, and 28.9 MPa with 7%, 5%, 10%, and 28.9% respectively. The alkali treatment causes fibrillation, which is a process that causes the fibre bundle to break into smaller bundles. Smaller bundles help to distribute the load applied throughout the fibres [9].

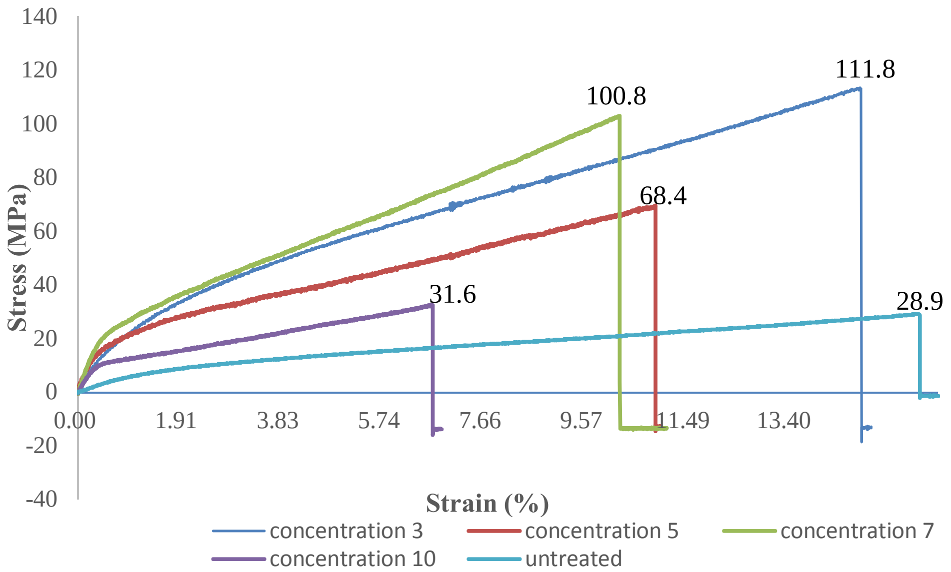

Figure 1. Stressï strain responses for untreated and treated of OPEFB fibres

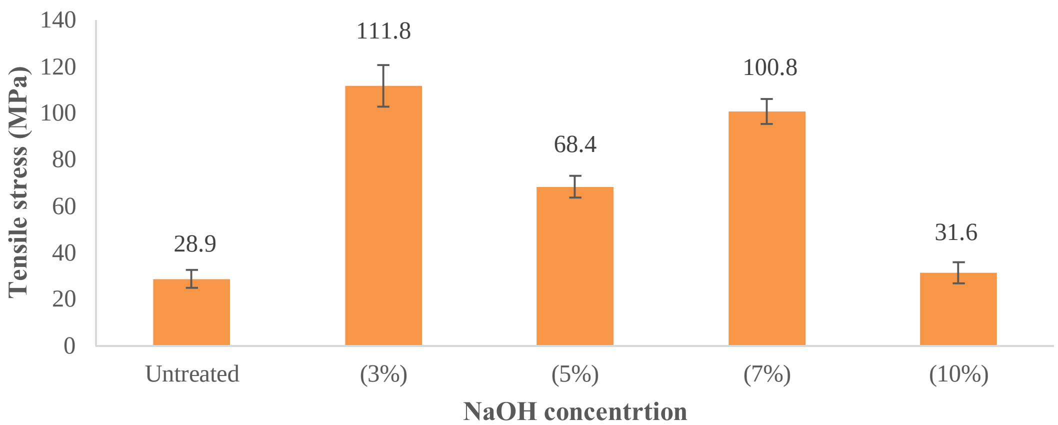

Figure 2. The average tensile stress of untreated and multiple treated of OPEFB fibres.

Based on Figure 3, the highest average Youngôs Modulus of OPEFB fibre recorded is 2.6 GPa 5% of NaOH concentration. While the lowest average modulus of elasticity is 3% with 0.6 GPa although previously it exhibited the highest tensile strenght. Seeing these results, the alkali treatment improved of the fibre elasticity compared with untreated fibres concerning the alkali concentration except for 3% of NaOH whereby reduced about 25%. However, after 5% treatment the modulus tremendously increased in the highest value before dropping for 1.8 GPa under 7% treatment. The modulus then indicates a slight increase for 2 GPa correlate with the increasing of alkali concentration in 10%. Hence, the different modulus elasticity may result in the different strain to failure of specific fibre.

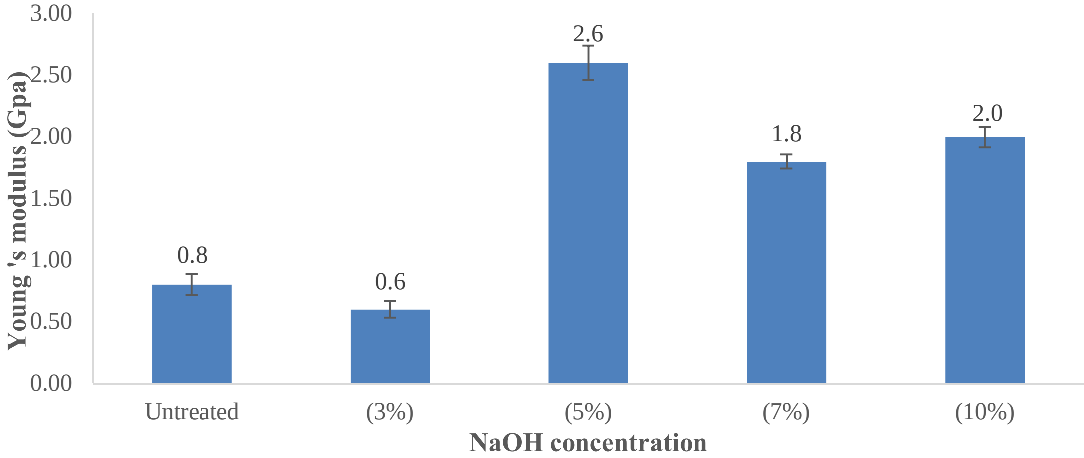

Figure 3. Youngôs Modulus of OPEFB fibres

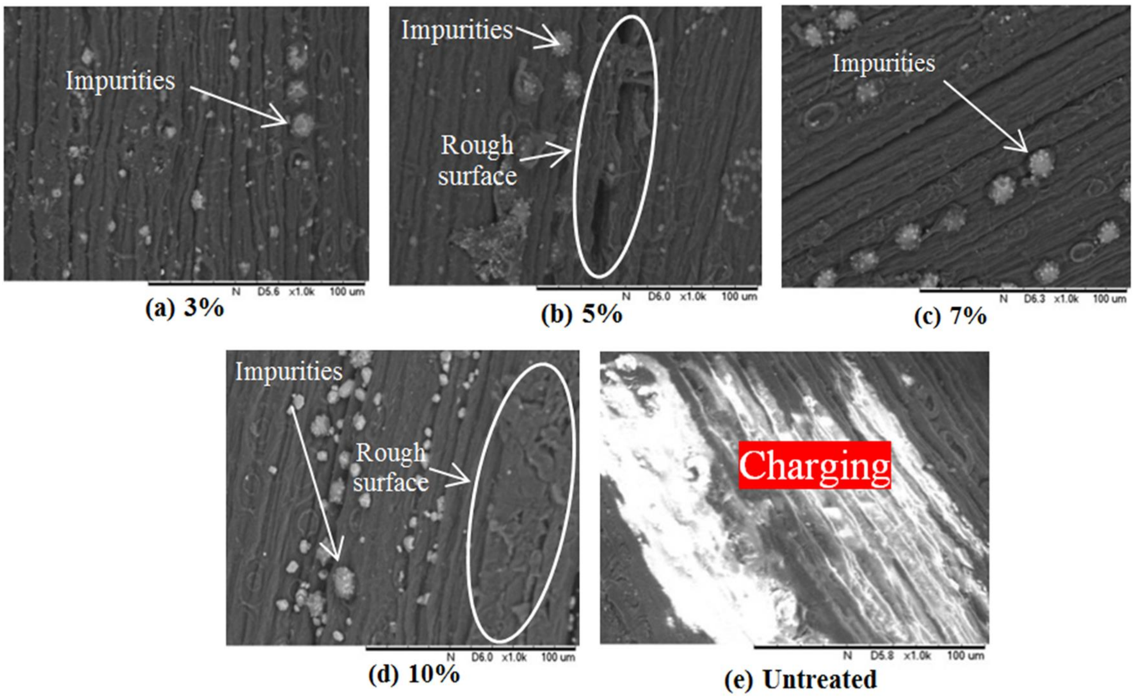

Figure 4. Surface morphologies for untreated and multiple treated of OPEFB fibres.

Figure 4 shows the SEM micrographs of the surface for untreated and treated OPEFB fibres. The treated fibres exhibit cleaner surfaces when the impurities reduced compared to untreated. The white spots in Figure 4 represent the presence of impurities on the surface of the fibres. However, the 5% and 10% NaOH concentration shows that the rough surfaces existed as depicted in Figure 4(b), (d) and its differ compare with 3% and 7% NaOH concentration which were smoother as shown in Figure 4(a), and (c). While Figure 4 (e) represents untreated fibers whereby clearly contain severe impurities, wax, fatty substances and globular pro- trusions called tyloses [11]. Based on this morphological observation, the alkali treatment caused the removal of impurities on the OPEFB fibres.

Conclusions

The mechanical properties of the treated and untreated OPEFB fibres with 2 hours soaking time accompanied by different NaOH concentrations were investigated in this paper. It is shown that the OPEFB fibres were increased in their tensile strength when treated in alkaline solution but slightly differ on Youngĝs Modulus when only 3% NaOH concentration shows the reduction compare to untreated fibre. The 3% NaOH concentration shown the highest tensile strength compared to the other soaking time and untreated fibre. The surface observation through Scanning Electron Machine (SEM) shows the texture of the fibres achieved the best result after alkaline treating when the impurities removed from the fibres. These results are quite promising as for further study to support the feasibility of utilising OPEFB fibres as reinforcing materials in polymer composites.

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