Effect of Alkali treatments on physical and Mechanical strength of Pineapple leaf fibres

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Abstract. Pineapple leaf fibre (PALF) is a waste material of pineapple plants. PALF is abundant in amount for industrial purpose, cheap, easily available, high specific strength and stiffness. PALF is contributing a sustainable development in bio-composites as reinforcement material. However, natural fibres are not fully compatible with matrix due to hydrophilic in nature. To enhance the compatibility with matrix, fibres are modified its surface to make good interfacial bonding with matrix. In this research, PALF is treated with 3% and 6% concentration of NaOH for 3h, 6h, 9h, and 12h soaking time. Surface modification of fibres was investigated by using scanning electron microscopy. Single fibre test and diameter of PALF fibres were evaluated the effects of NaOH treatments.

1. Introduction

There are many eco-friendly natural fibres, wood fibre and non-wood fibres being used to develop bio composites. Natural fibres are eco-friendly, minimum cost, less density, good mechanical properties, sound absorber and carbon dioxide sequestration over synthetic fibres[1]. Natural fibres extract from various sources such as leaves, fruit, grass and bast, which provide mechanical strength and stiffness of biocomposites in various applications [2]. Several industrial crop are being grown to collect fibres, it strengthen the supply of natural fibre for renewable materials and bio-composites[3]. There are some common natural fibres like flex, hemp, jute, kenaf, bamboo, sisal, and cotton being use for biocomposite. Pineapple leaf fibres (PALF) are waste material from pineapple cultivation. Annually, these waste material are available as a renewable cheap and abundant in amount for industries and researches purpose. PALF is the composition of high content of cellulose (70–82%) which is very higher than other natural fibres like oil palm frond, coir, and banana stem fibres while arrangement of PALF is the same as in cotton (82.7%) [4]. Higher cellulose content in PALF and its lower microfibrillar angle enhance the physical and mechanical strength of matrix reinforced biocomposites [5]. Many researchers [6-8] reported that some limitations of natural fibre reinforced thermoset/thermoplastics are natural fibre-matrix interfacial adhesion and hydrophilic nature of natural fibres. Lower fibre-matrix incompatibility effect the mechanical and physical strength of matrix reinforced composites and incapable to load transfer between fibre and matrix. There are various
treatments to increase interfacial adhesion capacity and less hydrophilic nature of natural fibre to enhance to mechanical properties of biocomposites [9]. In this study, alkali, treatments have been used on PALF fibres with various concentrations and immersion of time to modify its surface for good interfacial bonding with matrix. The aim of these treatments is to optimise chemical treatment of these fibres to make affective matrix reinforced composites.

2. Materials and methods
Pineapple leaf fibres (PALF) was collected and cleaned. The chemical used for treatments are NaOH (Sodium Hydroxide 6% w/v soln, R&M), from Jasa Sejiwa Enterprise.

2.1. Chemical treatment
PALF were immersed into distilled water with different chemical concentration with various period of soaking of time. NaOH concentration of 3% and 6% were used with four different soaking times having 3h interval (3h, 6h, 9h and 12h). After treatment, the fibres were thoroughly washed with running water several times until pH values are neutralized and dried in oven at 80°C temperatures for 48 h.

2.2 Scanning Electron Microscopy (SEM)
Morphology of untreated and treated PALF with different chemical concentrations and its various soaking time were investigated with Scanning Electron Microscope (SEM) machine Model HITACHI S-3400N.

2.3 Diameter Measurement
Diameter test was performed on untreated and treated PALF by using image analyzer. Accuracy of diameter measurement of natural fibres is very difficult to calculate due to irregular shape.

2.4 Tensile test
Untreated and treated PALF with different chemicals concentrations and immersion time were evaluated by Instron universal testing machine (UTM). According to the standard test method for single fibre tensile test ASTM D 3379 with speed of 1 mm/min. Before testing, fibres were examined to remove crack, partially break fibres by image analyser.

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T = \frac{F}{A} \quad \text{Eq. (1)}
\]

Where, T tensile strength in Pa, F force to failure in N, A average fibre area in m².

3. Result and discussion

3.1 SEM
SEM analysis observed effect the treatment of NaOH with concentration of 3% and 6% on PALF fibres. Untreated fibres carried many impurities on its surface shown in figure 1(a). PALF fibre treated with 3% concentration of NaOH with various type of period of soaking time showed different types of surface morphology. PALF fibres were soaked for 3 h in figure 1(b) revealed small impurity and smooth surface. Figure 1(c) showed rough surface with very less impurities. While figure 1(d) and 1(e) rough deeply and exposed cellulosic materials in comparison of untreated and figure 1(b) fibres. Fibres treated with 3% NaOH are still not effective enough to remove impurities from the fibre surface[10].
Figure 1. SEM of untreated (a) and 3% NaOH treated PALF fibre for (b) 3h, (c) 6h, (d) 9h and (d) 12h.

PALF fibre treated with 6% concentration of NaOH showed in figure 2(a) showed clean surface with some impurities on fibre surface and corrosive surface area. Soaked Fibre for 6h showed its clear surface with rough surface shown in figure 2(b). Figure 2(c) and 2(d) are very clean and clearly showed effect of chemicals on fibre surface. Higher concentration of NaOH can break hemicelluloses web of treated fibres, and separate fibres from fibre bundle [11]. After the separation of fibre, surface area of fibres increase and interaction of fibre/matrix also[12]. In figure 2 (a-d), there are many grooves like structures there because of removal of cementic material of fibre and its impurities are removed from the surface. These exposed areas enhance the surface of fibre which comes into contact with polymers and resulting better bonding [13, 14].

Figure 2. SEM of 6% NaOH treated PALF fibre for (a) 3h, (b) 6h, (c) 9h and (d) 12h.
Fibre treated with NaOH enhance the adhesion between fibre and polymer and mechanical properties of composites[15, 16]. The fibre treated with 6% NaOH is shown absence of impurities on the surface. While fibre treated with 9% NaOH is also clear with jagged and physically rough surface which make fibres very weak and brittle [10].

3.2 Diameter Measurement
Natural fibres are non uniform, structurally heterogeneous and may irregularities in shape [17]. It can be observed that treated fibre deduct its diameter in compare to untreated fibres. This reduction is expected because of NaOH treatment attack on amorphous surface of natural fibre and it removed impurities hemicelluloses and lignin [18].

![Graph showing diameter of untreated and treated PALF fibres.](image)

**Figure 3.** Diameter of untreated and treated PALF fibres.

Untreated fibres showed highest diameter than other treated fibre shown in figure 3. PALF fibre treated with 3% NaOH and 6% NaOH reduced its diameter. Among all the treatment, 6% NaOH treatment with soaking time 12 h showed smallest diameter. 3%NaOH treatment also decreased its diameter but fibre treated 6% NaOH showed better result. This study is clearly showed the effect of NaOH treatment on PALF fibres. Both treatments affect the fibre but 6% NaOH treatment for 12h showed lowest diameter.

3.3. Tensile strength
Figure 4 Showed effect of untreated and 6% NaOH treated fibres for 6h showed highest result among all the treatments while 3% NaOH treated fibres for 6h also showed a very good result. The treatments for 3 h are insignificant for both 3% and 6% NaOH treatments. 6% NaOH treatment for 6h is able to remove hemicelluloses and lignin and enhance surface area for fibre/matrix adhesion [19]. 3% NaOH treated fibre did not much affected with time but 6%NaOH treated fibre showed huge fall in tensile strength. From 6h to 12h, 3% NaOH treatment did not show much fluctuation though 6% NaOH treatment fall drastically and reached on its lowest point. Higher chemicals concentration may remove impurity efficiently but may decrease tensile strength due to lignocelluloses degradation and rupture of fibre surface [20].
Figure 4. Tensile properties of untreated and chemically treated PALF fibres

4. Conclusion
The 3% concentration of NaOH treatment did not affect the fibre and unable to remove impurities from the surface. However, at the soaking time 6h, 6% NaOH concentration removed the impurity and made the surface rough. Both 3% and 6% NaOH concentration effect diameter of fibre and after 12 h fibre soaking, the diameter was least. Both 3% and 6% NaOH concentration revealed higher tensile strength at 6 h soaking time. Beyond 6 h soaking time tensile strength of 6% NaOH were declined which showed negative impact of treatment. However, 3% NaOH sample was not affected very much due to lower concentration.

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