https://dx.doi.org/10.22161/ijaers.5.7.12 ISSN: 2349-6495(P) | 2456-1908(O)

The Effect of the Seawater Treatment on the Thermal and Morphological Properties of Oil Palm Empty Fruit Bunches Filled Poly (vinyl alcohol)

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Abstract— *Since Malaysia and the surrounding of the South East Asian countries has developed a large amount of oil palm EFB as a waste product after being processed as a fuel or other application, thus oil palm EFB fibre has displayed great potential as reinforcing material in polymer. The aim of this study to characterize the morphological and thermal effects of the seawater treated of oil palm empty fruit bunch single fibres and composites. The fibres of oil palm EFB has been treated using seawater from Pulau Tiga, at day-3 until day-30, the different filler loading of 1%, 3% and 5% of untreated and treated composites were prepared using casting method. The thermal properties of the composites of untreated and seawater treated were analysed using Thermogravimetric Analysis (TGA). Based on the thermal effect, Pulau Tiga composites have the good thermal stability due to the highest onset temperature. The morphological examined using Scanning Electron Microscopy (SEM). The morphological changes enhanced with the seawater treatment, however, at the filler loading of 5%, the composites easily cracked with more voids detected. In conclusion, seawater treatment significantly improved an extra enhancement in thermal stability and the morphological changes improved with the seawater treatment at 1% of the fibre loading.*

Keywords— ***Empty fruit bunch, sea water treatment and polyvinyl alcohol.***

I. INTRODUCTION

Polymer composites have been recognized in hundreds of new applications from sports equipment to Jet Ski, airplane body component, missile, spacecraft and marine applications. Further application include transportation, chemical equipment and machinery construction, electrical and electronics tools, fishing rods and storage tanks. Past research performed on the study of the oil palm fibre composites filled with both thermoset and thermosetting polymers. Other application include transportation, chemical equipment and machinery construction, electrical and electronics tools, fishing rods and storage tanks.

The studies focused on the electrical, thermal, mechanical, physical, and biodegradation properties (Shinoj *et al*., 2011). Currently, poly(vinyl alcohol) (PVA) resin plays an important role in the plastic industry as the core constituent for the manufacturing of composites. PVA is a synthetic polymer, which is biodegradable and biocompatible, which has great mechanical properties in application of tissue engineering (Ngadiman *et al*., 2015). A numerous of studies have been finished utilizing existing fibre surface treatment strategies to improve the interfacial bonding properties of diverse natural fibre reinforced composites (Sreekala and Thomas, 2003: Herrera-Franco, 2005: Van de *et al*., 2003). Conversely, only a few studies have completed in turn to find a new biological-based treatment that can to hunt down another organic-based treatment that can replace the chemical treatment. As the alternative, seawater treatment can be used to improve the mechanical properties of the biocomposites.

The objective of this study is to characterize the thermal and morphological properties of the sea water treated composites of oil palm empty fruit bunches filled with polyvinyl alcohol.

II. MATERIALS AND METHODS

The methodology of the research comprises of two main parts of the preparation of the composites and the characterization of thermal and morphological properties using Thermogravimetric Analysis (TGA) and Scanning Electron Microscopy (SEM). The preparation of composites involved the fabrication of composites of Oil palm EFB filled poly(vinyl alcohol) (PVA) using casting method. Oil palm empty fruit bunches were collected

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from Beaufort, Sabah, Malaysia, it is used as a filler. The oil palm EFB fibers were brownish in color with an average 0.175 ± 0.073 mm. The matrix used was poly(vinyl alcohol). The oil palm EFB composites of untreated and treated were prepared based on the blending formulation shown in **Table 1**. PVA powder (5-10 g) mixed with distilled water and diluted on hot plate at the consistent temperature of 90 °C for 2 h until it fully dissolved and became viscous and transparent. Untreated and treated EFB were milled at the size of ±3mm and transferred on the PVA solution for three different loading of 1%,3% and 5%, the mixture of filler and polymer placed in open mould with dimension (24 cm length x 12 cm width x 1 cm thick) and dried consistently at room temperature for 3 days. Lastly, the composites were cured over-night by compressing the top with the glass plate in order to maintain the uniform thickness and prevent bubbles produced in the samples. Seawater that used for the fiber treatment was taken from Pulau Tiga, Sabah, Malaysia. The seawater was located at South China Sea. The research area lies on the latitudes of 5°71' N and 5°80' N.

Table.1: Blending formulation of oil palm EFB on the respective fillers loading.

Component	PVA (g)	Distilled Water (mL)	Oil Palm EFB (treated) /g	Oil Palm EFB (untreated) /g
Neat	10.0	100.0	-	-
1%	9.0	90.0	1.0	1.0
3%	7.0	70.0	3.0	3.0
5%	5.0	50.0	5.0	5.0

III. RESULTS AND DISCUSSION

Thermogravimetric analysis of oil palm empty fruit bunches (EFB) filled poly(vinyl alcohol) (PVA) were studied as a function of percentage weight loss with temperature and shown in **Fig. 1** and **Fig. 2.** Generally, incorporation of plant fibers into polymeric matrix increases the thermal stability of the system. Increased thermal stability was also confirmed by the decrease in the activation energy of the composites (Shinoj *et al.*, 2011).

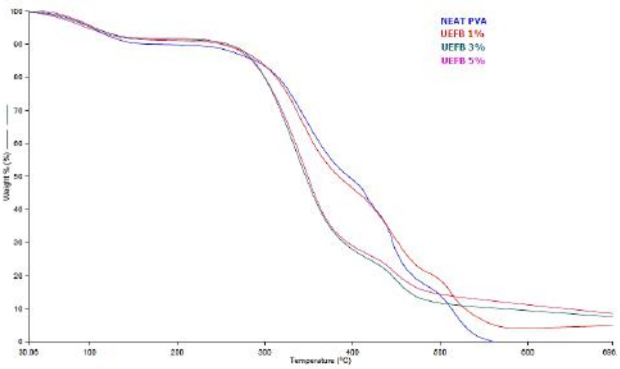

Fig.1: TGA of neat PVA and untreated oil palm EFB fibre filled PVA composite

The initial temperature, temperature at 50% of loss weight (maximum temperature) and final temperature the of composites are recorded at **Table 2**. The decomposition of neat PVA started at temperature of 30.28 °C and the final degradation occurred at 561.08 °C with maximum temperature at 50 % of decomposition happened at 395.24 °C. The untreated composites at 1% fibre loading start to decompose at the temperature of 30.39 °C followed by 30.06 for 3% and 5% fibre loading. The maximum degradation of the composites of 1, 3 and 5% fibre loading occurred at 384.32, 346.40 and 348.87 °C with the final temperature of 697.11, 696.58 and 696.49 °C respectively. The final temperature for the composites of Pulau Tiga recorded at the range of 697.10 until 697.32 °C, which is a little high that temperature at which neat PVA concluded degradation. The polymer interaction of interchain and intrachain of PVA makes it partially crystalline-structured polymer due to the H-bonding in between hydroxyl groups (Gaaz *et al.*, 2015).

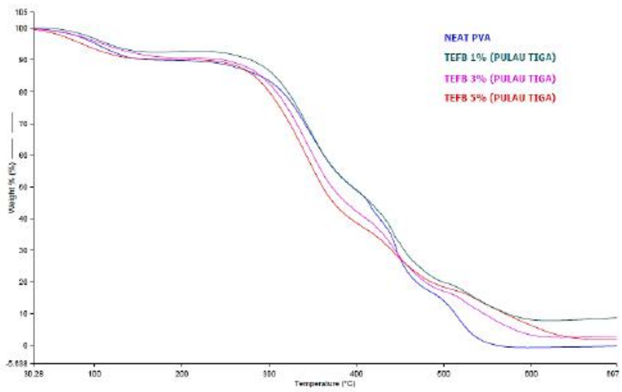

Fig.2: TGA of neat PVA and seawater treated (Pulau Tiga) oil palm EFB fibre filled PVA composite.

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Table.2: Initial temperature, temperature of 50% weight loss and maximum degradation temperature of neat, untreated and seawater treated of oil palm EFB composites at different fibre loading.

	Filler loading (%)	***T_i(°C)**	****$T_{50\%}$(°C)**	*****T_f(°C)**
Neat PVA	0	30.28	395.24	561.08
Untreated	1	30.39	384.32	697.11
	3	30.06	346.40	696.58
	5	30.06	348.87	696.49
Pulau Tiga	1	30.38	394.28	697.10
	3	30.30	371.32	697.24
	5	30.64	365.27	697.32

*Ti initial temperature, **$T_{50\%}$ temperature at 50% weight loss and ***T_f final temperature

As can be observed, the fibre loading had a very small impact on the composites melting temperature than neat PVA with 395.24 °C. In contrast to neat PVA, the $T_{50\%}$ of the composites decreased as the fibre loading increased. This indicates that the thermal stability of neat PVA increased with the addition of oil palm EFB fibre at 5% fibre loading. More heat energy absorbed by a filler in the melting of the composites (Essabir *et al.*, 2016).

The surface morphology of the untreated and seawater composites at different fibre loading shows at the Figure 3 (a), (b), (c), and Figure 4 (a), (b), (c) respectively. From Figure 3 (a), the untreated oil palm EFB composites at 1% filler loading shows the oil palm EFB fibre disengaged from the surface of matrix, as a result of weak interfacial adhesion and cracks that formed on the matrix surface. The cracks observed from the oil palm EFB composites filled PVA cause the oil palm EFB fibre to pull out from the matrix and thus causing a failure. This damage can be overcome by right composition of PVA matrix with a right filler loading of oil palm EFB fibres (Sathish *et al.*, 2015).

This observation demonstrates that the untreated oil palm EFB fibre has poor interaction with the matrix. The cementing materials at the surface of untreated oil palm EFB fibre composites also contribute to the unsuccessful fibre-matrix bonding and poor wetting (Jayaramudu *et al.*, 2014). As been shown in **Fig. 3** (b) and (c), it can be observed that the formation of holes as well as the fibre pull out from the matrix.

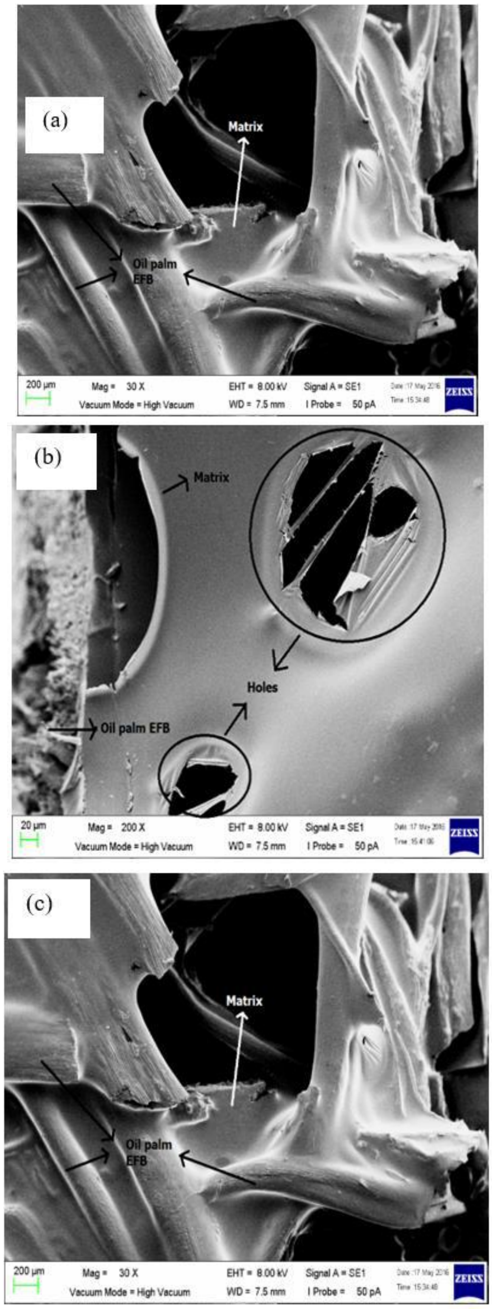

Fig. 3: *SEM micrograph of untreated composites of different filler loading (a)1% ; (b)3% ; (c)5%.*

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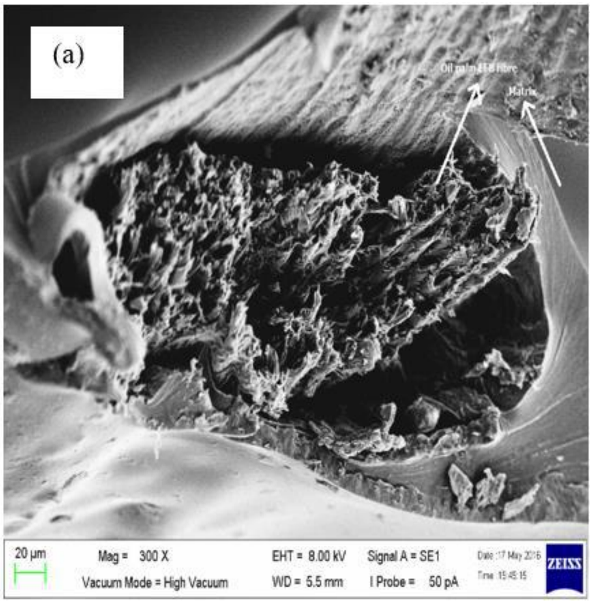
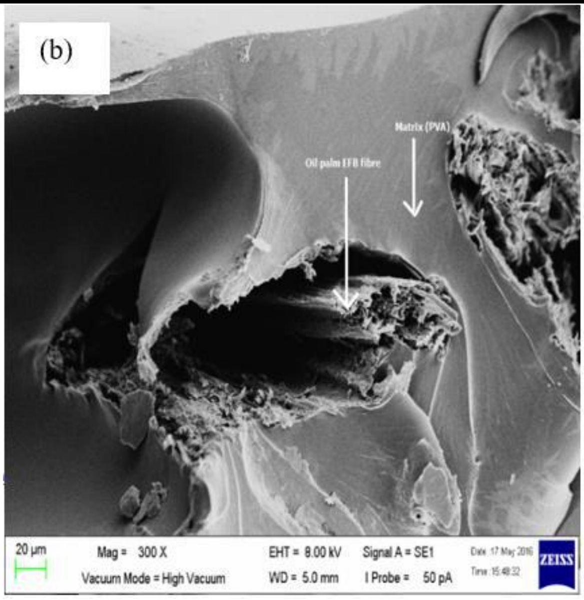
Seawater treated composites of Pulau Tiga are shown in **Fig. 4**, at different fibre loading of 1, 3 and 5%. **Fig. 4(a)** shows that the oil palm EFB fibres attached smoothly to the matrix, this can be concluded that the interaction of the oil palm EFB fibre and the fibre matrix at the fibre loading of 1% gives good interfacial bonding, which gives the highest tensile strength among all the composites.

The oil palm EFB fibres shows good intact with the PVA matrix, these suggest that there is good wetting of the fibres by PVA matrix. In addition, less holes and cracks observed at the surface of matrix at the **Fig. 4(b)**, this indicates better interfacial bonding between the fibre and matrix. **Fig. 4(c)** indicated that the surface of seawater composites shows a fibre breakage instead of fibre pull-out, which indicates better interfacial strength between the matrix (Annie *et al*., 2008).

At the filler loading at 5% the tensile strength declined as there is a holes indicated at the fibre surface. However, the strong interaction between the fibre and matrix confirmed by the present of the fibre pull-out from the matrix as well as the crack formation by the force. This may be due to the hydrogen bonds that formed within the hydrophilic surface groups of the oil palm EFB fibre and the oxygen-containing species in the PVA matrix (Alzeer and Mackenzie, 2013).





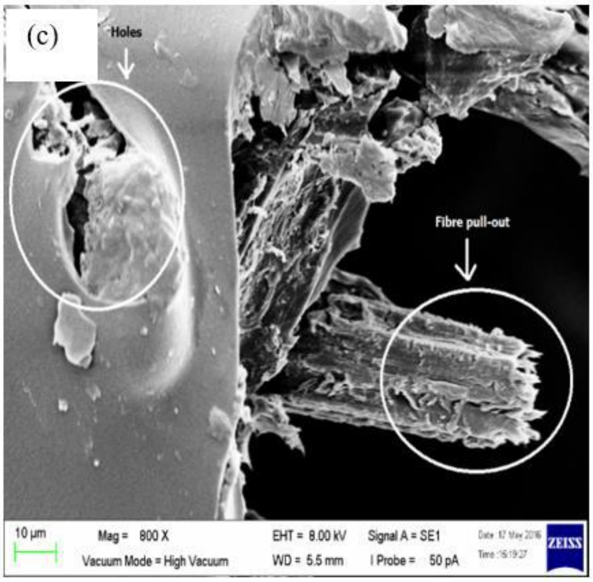


Fig. 4: *SEM micrograph of treated composites of different filler loading (a)1% ; (b)3% ; (c)5%.*

IV. CONCLUSION

Seawater treatment can be used as nature treatment of the fibre that bring to the same result as the chemical treatment such as alkali treatment. The composites of the untreated and treated filled PVA was fully fabricated. The characterization of the composites was characterized Scanning electron microscopy (SEM) and Thermogravimetric analysis (TGA). The morphological properties of single fibres and composites were clearly showed upon the treatment. The seawater treated single fibres has smooth surface than the untreated single fibres, this is due to the removal of the outer layer of hemicellulose, lignin and pectin. The seawater treated composites shows the good interfacial bonding with the PVA matrix than the untreated composites. The thermal stability of the composites enhanced as the fibre loading increased at 5%. Seawater treatment can be used as the alternative to replace the chemical treatment of the fibres due to the same effect arise from the treatment.

ACKNOWLEDGEMENTS

Thanks for the Universiti Malaysia Sabah for the facilities. This work was financial supported by RAG0060-TK-2014 and SLB0088-TK-2014 grant.

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