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Oil Palm EFB/Kenaf Fibre Reinforced Epoxy Hybrid Composites: Dimension Stability Behaviours

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Abstract. In recent years, natural fibres composites have gained increasing interest as a most promising material in different applications due to its attractive properties such as eco-friendly, cost-effectiveness and light weight. Though extensive research has been made on the performance evaluation of natural fibres composite materials, not much data is available on the dimension stability which restricts their use in exterior applications. In this study, hybrid composites were fabricated by hand lay-up technique by reinforcing oil palm empty fruits bunch (EFB) and kenaf fibre mats with epoxy matrix. Experiments are evaluated to study dimension stability that includes water absorption, thickness swelling, density and void content. Increasing the kenaf fibre into EFB composite totally improves the dimension stability of the hybrid composites thus indirectly leads to reduction in voids compared to oil palm EFB composites which is presented lowest percentage of dimension stability and higher void content.

1. Introduction

Natural fibres have been attracted for industries applications such as automotive compartment, sport equipment, construction materials and non-structural elements due to its renewable nature, low cost, easily availability, low density, biodegradable nature, easy fibre surface modification, wide availability and relative non-abrasiveness [1,2]. Previously, lot of works and developing of natural fibres composites have been done by combining using different types of fibres and various resins [3]. One of the natural fibres is oil palm empty fruit bunch (EFB) fibre that found a lot in Southern Asian countries and Malaysia is one of the biggest palm oil exporters in the world with having 50,000 km^2 of oil palm plantations and 423 palm oil mills operating in the country [4,5]. Oil palm fibre is hard and tough, which shows similarity to coir fibres. With average diameter 0.07 µm. of pores on fibre surface is useful for better mechanical interlocking with matrix resin in composite fabrication [6]. Despite the advantages, one of the important issues of natural fibre is the hydrophilic property of cellulose which impacts the weak interface bonding with hydrophobic polymer as a matrix [7]. Most of the drawbacks that have been identified can be overcome by effective hybridization of natural fibre with synthetic or natural fibres [8,9,10,11,12,]. Hybridization, especially where only variant natural fibre are combined, is fast receiving encouraging attention because it offers a range of properties that is quite difficult to obtain with single kind of reinforcement [13]. In the present study, oil palm EFB with kenaf fibre reinforced epoxy resin was prepared by using hand lay-up technique. Void content, density, water absorption and thickness swelling behaviors were studies. The main objective of this study is to investigate the effectiveness of hybridizing kenaf into oil palm EFB through dimension stability behaviors.

2. Experimental

2.1. Materials

Oil palm EFB mats were supplied by HK Kitaran Sdn. Bhd. (P.Pinang, Malaysia) while non-woven kenaf fibre mats were supplied by ZKK Sdn. Bhd. (Selangor, Malaysia) . The liquid epoxy resin DER-331 used in this study is based on epichlorohydrin and bisphenol A and the curing agent was epoxy hardener joint amine 905-3s. Silicon spray was used as a release agent. Resin, curing agent and silicon spray were procured from TAZDIQ Engineering Sdn. Bhd. (Selangor, Malaysia).

2.2. Preparation of the composites

Fabrication of oil palm EFB/kenaf fibre reinforced epoxy hybrid composites using stainless steel mould with dimension 300 mm x 300 mm x 5 mm. Hand-lay-up technique was chosen for making test sample. Silicon spray was coated with thin layer which act as a releasing agent. Epoxy resin and hardener uniformly mixed using ratio 2:1 for 15 minutes. Hybrid composites were prepared by hybridizing oil palm EFB and kenaf fibre with keeping the different weight ratio of oil palm EFB and kenaf fibre 4:1, 1:1, and 1:4 with total fibre loading at 50% by weight. Oil Palm EFB and kenaf fibres mat were stacking alternating in the mould, then were poured with resin matrix. The composite was pressed with a hand roller to eliminate any entrapped air bubbles. The mould was closed for curing process using hot press machine at pre pressed 5 minutes, compressed for 15 minute at 120oC. Hybrid composites were then cooled in cold press for 5 minutes. Single oil palm EFB and kenaf fibre composites also prepared as a control samples.

3. Characterization

3.1. Void Content

For determination of void contents in composites, ASTM D2734 method was used. The void content was determined from the theoretical and experimental density of the composite through Equation (1),

$$VoidContent(\%) = \frac{P_{theoretical} - P_{experimental}}{P_{theoretical}}$$

$$Where\ P_{theoretical} = \frac{1}{[(W_f/P_f) + (W_m/P_m)]},$$

And W_f is the fibre weight fraction, W_m is the matrix weight fraction, P_f is the fibre density and P_m is the matrix density.

3.2. Density

Density was measure by using the ASTM D1895 standard. The density of the samples was calculated by using following Equation (2),

$$Density(g/cm^3) = m/v$$

Where m is the mass of the composites, and v is the volume of composites.

3.3. Dimension Stability Test

The dimensional stability tests involved thickness swelling and water absorption according to ASTM D 570. Before testing, the weight and thickness of each sample were measured. Five samples of each type of composites were immersed in distilled water at room temperature. After 24 hours, the sample was taken out gently blotted with filter paper to remove excess water on the surface. The weight and thickness samples were recorded and were continue for several days until a constant value of the samples was obtained. The percentage of water absorption was calculated from equation (3) and for the thickness swelling was equation (4),

$$WaterAbsorption(\%)=\frac{W_n - W_d}{W_d}$$

Where W_n is the weight of composites samples after immersion and W_d is the weight of the composite samples before immersion.

$$Thickness\ Swelling\ (\%) = \frac{T_1 - T_0}{T_0}$$

Where T_1 is the thickness after soaking and T_0 is the thickness before soaking.

4. Results and Discussion

4.1. Void Content and density

Table 1 shows the void content and density of oil palm EFB/kenaf fibre reinforced epoxy hybrid composites. Oil palm EFB showed higher voids and low density respectively. It is clearly showed that oil palm EFB composites attributed to poor fibre-matrix dispersion and wetting of the fibres occur. According to Jawaid et al. [14] the most common cause of voids is the incapability of the matrix to displace all the air which is entrained within the fibre as it passes through the matrix impregnation. High voids in the composite leads to lower fatigue resistance, greater susceptibility to water absorption, and increased variation in mechanical properties [15]. In addition, oil palm fibre are porous and the mat is loosely packed hence a large amount of resin would be squeezed out of the mat during pressing molding. The percentage of void content reduced when additional of kenaf fibre into oil palm EFB fibre which is contributed by higher density of kenaf compare to oil palm EFB fibre. Kenaf fibre mats are tightly packed and also more compatible towards the epoxy resin. As the result, slightly fewer amounts of voids and density percentage are present in the hybrid composites between hybrid parameter respectively.

Table 1: Void content and density of Oil Palm EFB/Kenaf Fibre Reinforced Epoxy Hybrid Composites

Composites	Void Content (%)	Density (g/cm^3)
Pure EFB	8.40	1.02
EFB: Kenaf (1:4)	4.43	1.10
EFB: Kenaf (1:1)	6.15	1.07
EFB:Kenaf (4:1)	3.20	1.16
Pure Kenaf	2.50	1.21

4.2. Water Absorption

In general moisture diffusion in a composite depends on factors such as volume fraction of fibre, voids, viscosity of matrix, humidity and temperature [16]. Figure 1 shows the trend of water absorption of oil palm EFB/kenaf fibre reinforced epoxy hybrid composites. As can been seen, the water absorption increased with immersion time. Pure oil palm EFB composite indicates highest among the different type of composites. This exhibits high porosity or presence of voids on the surface of oil palm EFB composites. According to Chinomso et al. [17] study, amount of water absorbed at any given fibre loading of oil palm EFB composites and the hydrophilic nature of oil palm EFB fibre is believed to be responsible for the water absorbed by the composites. Khalil et al. [8] stated that oil palm EFB fibres contain a higher proportion of hemicelluloses, owing to the free hydroxyl group present which are higher water absorption and hydrophilic nature fibre. According to Azman et al. [18], hydroxyl group is the main chemical entity for the attraction of water molecules in the natural fibres which is absorb water through formation of hydrogen bonding. Hybridization of kenaf fibre into oil palm EFB fibre decreased water absorption of the oil palm EFB fibre. This is mainly attributed by packed arrangement of hybrid composites and the less hydrophilic nature of kenaf fibre as compared to oil palm EFB fibre.

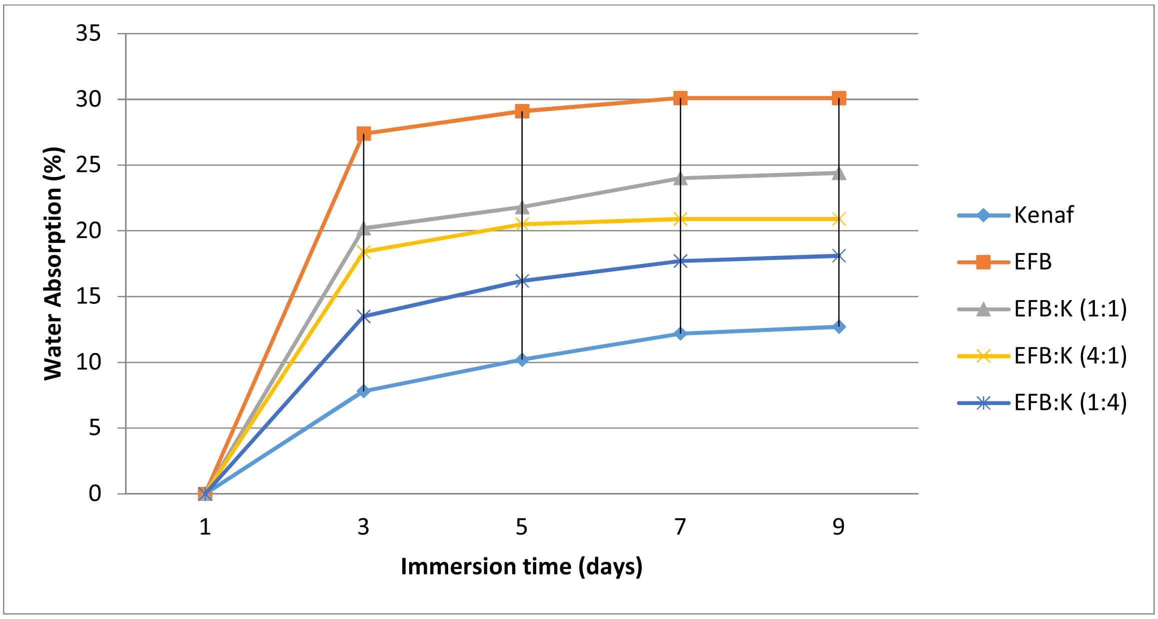

Figure 1: Water absorption (%) of oil palm EFB/kenaf fibre reinforced epoxy hybrid composites.

4.3. Thickness Swelling

Thickness swelling is closely related to the dimensional stability of the composite. When the composite is exposed to different humidity and temperature, stress is induce in between the layers of composite resulting in degradation of fibre matrix. The uptake of the water changed the thickness and affects the dimension of the composite [5]. Thickness swelling was carried out for several days until a constant weight was obtained. From the figure 2, it is observed that thickness swelling of oil palm EFB composite was highest among the different type of composites. It also showed the thickness swelling values of composites increased with an increased of water absorption time. By increasing the exposure time of composites to water, a significant amount of water absorbed, resulting in the swelling of fibre. Similar trend with water absorption, oil palm EFB indicates hydrophilic properties that responsible for the changes in the dimension of cellulose based composites particularly in the thickness and linear of the composite. In contrast, pure kenaf fibre composite shows moderate thickness swelling and slightly different with the hybrid composites. Hybridizations of oil palm EFB with kenaf fibre caused a remarkable reduction in thickness swelling rate. This can be expected to depend on the exposure of lignocellulosic fibre on the surface of composite [8].

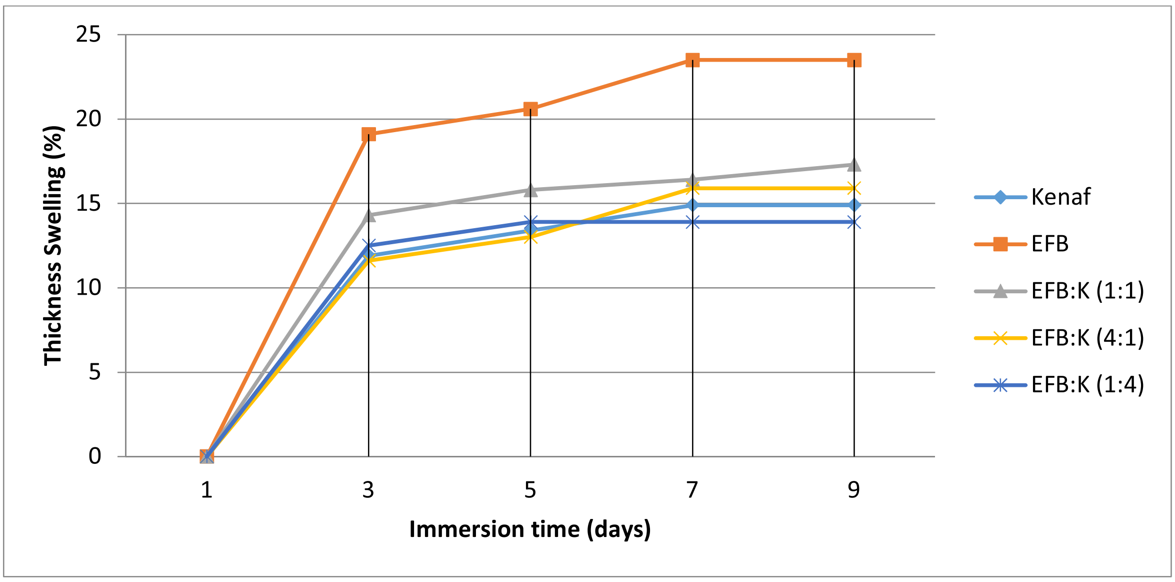

Figure 2: Thickness swelling (%) of oil palm EFB/kenaf fibre reinforced epoxy hybrid composites.

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5. Conclusions

Oil palm EFB composites showed the highest percentage of all dimension stability behaviors. Hybridization of kenaf fibre into oil palm EFB composite significantly reduced void content and increased the density of hybrid composites. Increasing the kenaf fibre in the composite shows improvement the amount of thickness swelling and water absorption of the hybrid composites decreased due to packed arrangement of hybrid composite and less hydrophilic nature of kenaf fibre compare to oil palm EFB fibre.

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References

[1] Shaji J., Sreekumar P.A, Jose M.K, Debora P., Sabu T., and Kuruvilla J. “Oil palm microcomposites: Processing and mechanical behavior,” *Soc. Plast. Eng.*, **50**, pp. 1854-1863, 2010.

[2] Reza M., Jamaludin M.Y., Abdul R.M.S., and Sayed H.H. “Tensile properties of kenaf fibre due to various conditions of chemical fibre surface modifications,” *Constr. Build Mater.*, **55**, pp. 103-113, 2014.

[3] Jawaid M. and Abdul Khalil H.P.S. “Hybrid composites made from oil palm empty fruit bunches/jute fibres: Water absorption, thickness swelling and density behaviours,” *J. Polym. Environ.*, **19**, pp. 106-109, 2011.

[4] Tye. Y.Y., Lee. K.T., Wan. N.W.A. and Leh C.P.” The effect of various pretreatment methods on oil palm empty fruit bunch (EFB) and kenaf core fibres for sugar production,” *Procedia Environ. Sci.*, **20**, pp. 328-335, 2014.

[5] Teh W. F., Nurin S.S.N.A., Abdul Khalil H.P.S., Mohamad H.M.K., and Syakir M.I.” Water Absorption and thickness swelling of oil palm empty fruit bunch (OPEFB) and seaweed composite for soil erosion mitigation.” *J. Phys. Sci.*, **28**, pp. 1-17, 2017.

[6] Shinoj S., Visvanathan R., Panigrahi S., and Kochubabu M.,“Oil palm fibre (OPF) and its composites: A review,” *Ind. Crops Prod.,* **33**, pp. 7-22, 2011.

[7] Reza M., Jamaludin M.Y., and Abdul R.M.S.” A review of structural performance of oil palm empty fruit bunch fibre in polymer composites,” *Adv. Mater. Sci. Eng.*,” pp. 1-9, 2013.

[8] Abdul Khalil H.P.S., Jawaid M., Abu B. A.” Woven hybrid composites: Water absorption and thickness swelling behaviours,” *Bioresour.*, **6**, pp. 1043-1052, 2011.

[9] Abu B., Ahmad M. A., and Kuntjoro W. "The mechanical properties of treated and untreated kenaf fibre reinforced epoxy composite," *J. Biobased Mater. Bio*., **4**, pp. 159-163, 2010.

[10] Alves, C., Ferrao P.M.C., Silva A.J., Reis L.G., Freitas M., Rodrigues L.B., and Alves D.E. "Ecodesign of automotive components making use of natural jute fibre composites," *J. Clean. Prod*., **18**, pp. 313-327, 2010.

[11] Jawaid M., and Abdul Khalil H.P.S."Cellulosic/synthetic fibre reinforced polymer hybrid composites: A review," *Carbohydr. Polym*., **86**, pp. 1-18, 2011.

[12] Sapuan S.M., Harun N., and Abbas K.A."Design and fabrication of a multipurpose table using a composite of epoxy and banana psedostem fibres," *J. Trop. Agric.,* **45**, pp. 66-68, 2007.

[13] Aji I.S., Zainudin E.S., Khalina A., Sapuan S.M.,"Studying the effect of fibre size and fibre loading on the mechanical properties of hybridized kenaf/PALF-reinforced HDPE composite," *Reinf. Plast. Compos*, **30**, pp. 546-553, 2011.

[14] Jawaid M., Abdul Khalil H.P.S., Abu B.A., and Noorunisa P.K."Chemical resistance, void content and tensile properties of oil palm/jute fibre reinforced polymer hybrid composites,' *Mater. Des*., **32**, pp. 1014-1019, 2011.

[15] Jawaid M., Abdul Khalil H.P.S., Hassan A. and Elgorban A." Bi-layer hybrid biocomposite: chemical resistance and physical properties," *Bioresour.*, **7**, pp. 2344-2355, 2012.

[16] Dhakal H.N., Zhang Z.Y., and Richardson M.O.W.,"Effect of water absorption on the mechanical properties of hemp fibre reinforced unsaturated polyester composites," *Compos. Sci. Technol.*, **67**, pp. 1674-1683, 2007.

[17] Chinomomso M.E. and Isaac O.I." Properties of oil palm empty fruit bunch fibre filled high density polyethylene," *Int. J. Eng. Technol.,* **6**, pp. 458-471, 2012.

[18] Azman H., Arshad A.S., Farid N.A., and Aznizam A.B."A review on oil palm empty fruit bunch fibre-reinforced polymer composite materials," *Polym. Compos*., **31**, pp. 2080-2101, 2010.