Indian Journal of Science and Technology, *Vol 11(13), DOI: 10.17485/ijst/2018/v11i13/92794*, April 2018
ISSN (Print) : 0974-6846
ISSN (Online) : 0974-5645

The Future Quality of Natural Fibre – Matrix for Green Composites: An Environmental Credential

Flora Elvistia Firdaus*

Department of Chemical Engineering, Jayabaya University, Jakarta – 13201, Indonesia; flora_elvistia@yahoo.com

Abstract

Objectives: The use of green composite on this study has faced poor compatibility of natural fibre to the matrix. Fibre surface modification is done to enhanced adhesion of epoxidized bio-resin vegetables oil based onto bamboo fibre. **Methods:** Alkylation is the method was used to modify fiber surface by soaking the bamboo fiber into NaOH solutions under designated varied of concentration and time. The goals are to get rough surface to enhanced adhesion and improved mechanical strength of green composite. **Findings:**The optimum concentration of alkylation to fibre volume fraction are complementary influenced the green composite mechanical properties. **Applications:** The products obtain can be used in wide ranging of applications. The low cost of production may have great opportunity for developing countries.

Keywords: Alkilation, Bamboo Fibre, Environmental, Epoxy Resin, Green Composite

1. Introduction

The interest of using bio-derived products has been driven the need for replacing petroleum based[1,2]. These tendencies of using matrix and reinforcement material from sustainable products.

Vegetable oil represent a renewable resources which can be used as reliable material to access new products with wide array of many structural and functional.

1.1 Theory of Composite

The term composite generally refers to high performance, extremely strong, and light materials injected with epoxy resin. The functions of matrix are to transfer load, to prevent mechanical, and environmental damages in the form of thermosetting and thermoplastics. It may be derived from vegetable epoxidized resin which reinforced by bamboo, jute, or sissal fibres. One major drawback of using vegetable oil for bio-based resins is lead to low crosslink density existence network compared to petroleum based[3]. The Chemical composition of natural fibre can be seen in Table 1.

Table 1. The chemical composition of natural fibres[3]

Fibres		Microfibril angle (deg)	Cellulose (%)	Lignin (%)
Coir		30-49	53	45
Banana		11	65	5
Sisal		20-25	70	12
Jute		8.1	63	11.7
Bamboo		2.0-10	60.8	32.2

The disadvantages of using bio-fibres are due to high moisture content, especially cellulosic fibres which lead to poor dimensional stability and process ability, porous issues, and as if exposed outdoors may bio-degrade by ultraviolet light, the dispersion of natural fibres which affected by strong inter fibre bonding, and incompability between hydrophobic polymer matrix and hydrophilic natural fibres. These may lead to poor matrix-fibre bond which overall are related to material performances. Alkali treatment can overcome and minimalized problems by modifying fibers surface[4–6]. The property of selected natural fiber can be seen in Table 2.

*Author for correspondence

Table 2. Property of selected natural fiber[4]

Property	Hemp	Flax	Sisal	Jute
Density(gr/cm3)	1.48	1.4	1.33	1.46
Modulus (GPa)	70	60-80	38	10-30.0
Tensile Strenght (MPa)	550-900	800-1500	600-700	400-800
Elongation to Failure (%)	1.6	1.2-1.6	0.2-0.3	1.8

2. Materials and Methods

2.1 Material

The vegetable oil was obtained from local grocery; soybean oil was manufactured by Salim Ivomas Jakarta, and canola oil was produced by Switzerland AG Coda. The epoxidized of vegetables oil were synthesized *in situ* by using peracetic acid.The product obtained perform as bio-resin, with ratio (2:1) are blended to epoxy resin and hardener; a product of Polychem Jakarta. The curing process observed is achieved in the shortest amount of time.

2.2 Methods

The matrix used are manufacture from soybean oil and canola oil. They are respectively in the form of epoxide-based resin which are considered to be potential material for substituting petroleum based. For this, the composite were made by hand lay-up technique.

The important aspect of producing green composite are to be considered; the adhesion between matrix and fibre which can be effected to some numerous mechanical properties.

The variables which directed to the toughnesses of composite is the Weight fraction (Wf) and Volume fraction (Vf). The balanced performance are needed to prevent the fibre damage leading to composite failures. The objective of this research is to produce tough composite with good mechanical properties. In accordance with the obtained results, good adhesion between fibre and matrix.

2.3 Alkali Preparation

The presence of lignocellulosic in the fibre are chemically strong bonded by non covalent forces. This lignocellulosic makes them partially degraded. To obtain good and strong composite, the fibre surface are chemically modified with NaOH in order to enhance bonding compatibility between fibre and matrix.There concentration prepared are; 5 10, 15, 20, and 25 % (v/v). The 0% (v/v) are used for control variable.

2.4 Composite Preparation

Bamboo is an ancient woody grass widely distributed in tropical, subtropical, and mild temperate zones. There are about 1200 species of bamboo in some 90 genera. The occurrence of bamboo in Indonesia is recorded about 135 species. Bamboo forest are found in East Java, some species grows dominantly in Kalimantan and Sulawesi[7]. The bamboo fibre used in this research was string bamboo, the scientific named known as *Gigantochloa Apus*. It cultivated in Eastern part of Bogor in West Java, Indonesia. The ingredients of the matrix; epoxy of vegetable based are blends to epoxy resin and hardener and were mixed in laboratory glassware, then stirred. The products obtained are known as resin, are then poured onto fiber surface where are previously treated with NaOH.

2.5 Testing of the Composite

The test samples were cut out then tested according to ASTM standard. The tensile strenght was done as per ASTM D3379 using a universal Shimadzu with cross-head speed of 2 mm/minute. Bending strenght was done by ASTM D3379 with pressure rate 1.651 mm/minute. Compressive strenght was done by ASTM D3039 with pressure rate 1.3 mm/ minute. The cellular images was done after tensile test is achieved using Philip SEM-DX XL30 with ASTM D3036.

3.Results and Discussion

3.1 Tensile Strenght vs Volume Fraction

The tensile properties of bamboo/epoxy bio-composites were reveal the effects of volume fractionof bamboo fiber and its alkali treatment on bamboo/epoxy interface and tensile strenght. Tensile of untreated alkali of corn oil based resin are eventually higher than sunflower, canola, and soybean based-resin[8]. As the volume fraction of fibre increase to 79.7 % (v/v),the tensile strenght of composite using soybean-based resin is higher among others. The tensile declined from 10% (v/v) of alkali treatment.

3.2 Elongation at Break vs Volume Fraction

The elongation at break of composite using vegetable oil based resin; soybean and canola are found has resulted different responses to the varied volume fraction of fiber, which met its optimal volume fraction for soybean oil in the range of 76.7-78.6 (%) and for soybean in the range of 80-80.9(%).This volume fraction are complementary synergized to the concentration of alkali treatment to fibre surface. It is found the soybean based resin has reached its highest level by 5 % (v/v) of alkali treatment; the elongation was 7.58% and the tensile strength is 208.74 MPa. While for the same concentration of the alkali treatment, the elongation of canola based is 3.32 % and tensile strength 81.88 MPa. As compared to the same concentration of alkali applied onto fiber with sunflower and corn based resin the result are respectively for elongation at break declined to 3.06% and corn based resin was 2.96% where the alkali treatment are negatively impacted to its mechanical properties, as can be noted for any concentration of treatment the composite obtained has poor mechanical properties[8]. Conversely happened to soybean and canola based resin, as can be seen in Table 3.

Table 3. Tensile strenght and elongation of composite

Type of Oil	Fiber surface	Tensile Strength	Elongation	Vf
	Alkylation	[MPa]	[%]	[%]
	(%,v/v)			
Soybean	0	49.04	3.15	76.7
Soybean	5	208.74	7.58	79.7
Soybean	10	93.93	4.14	78.6
Soybean	25	90.62	1.62	76.4
Canola	0	106.68	7.15	80
Canola	5	81.88	3.32	76.8
Canola	10	109.54	7.59	80.3
Canola	25	43.45	1.16	73.7

Overall, the tensile strenght and elongation at break of bio-composite with treated alkali are only recommended for soybean for concentration 5% (v/v) and canola with concentration 10% (v/v). The treatment causes fibre roughness which increases the effective of surface availability to be perfectly wetted by the matri[9–14].

3.3 Compressive Modulus, Compressive Strenght

The compressive strength resists compression to being pushed together. Canola based resin resulted the highest compression strenght amongst other oil by 5% (v/v) of alkali treatment, though its quite similar to without alkali treatment.

The compressive strength of the material correspond to the stress value of material. In a compression test, there is a linear region where the material follows Hooke's Law. The material deforms elastically and returns to its original length when the stress is removed. Overall, the compressive of composite are lower at any kind of resin based and any concentration of alkali treatment than its tensile strenght as summarized in Table 4.

Table 4. Compressive strenght vs alkali treatment

Type of Oil	Alkali (%,v/v)	Compressive Strength [MPa]	Compressive Modulus [GPa]
Soybean	0	37.2	2.24
	5	30.62	2.8
	10	27.15	4.14
	25	18.27	2.52
Canola	0	39.68	2.76
	5	39.03	2.44
	10	11.98	2.87
	25	21.9	2.52

3.4 Bending Strenght, Bending Modulus

The bending strength would be the same as the tensile strength if material were homogeneous. The small or large defects will concentrate stresses locally, which effectively caused tolocalized weakness. If free from defects, the flexural strength will be controlled by the strength of those intact fibers. The material which subjected to only tensile forces test then at the same stress and failure will initiate when the weakest fibre reaches its limiting tensile stress. Bending strenght of PLA/ bamboo alkali treated is 98 and non treated is 82[15]. In this research we found the bending reached the highest 105.5 MPa using canola based resin with 10% (v/v) of alkali treatment but lower than its ten-

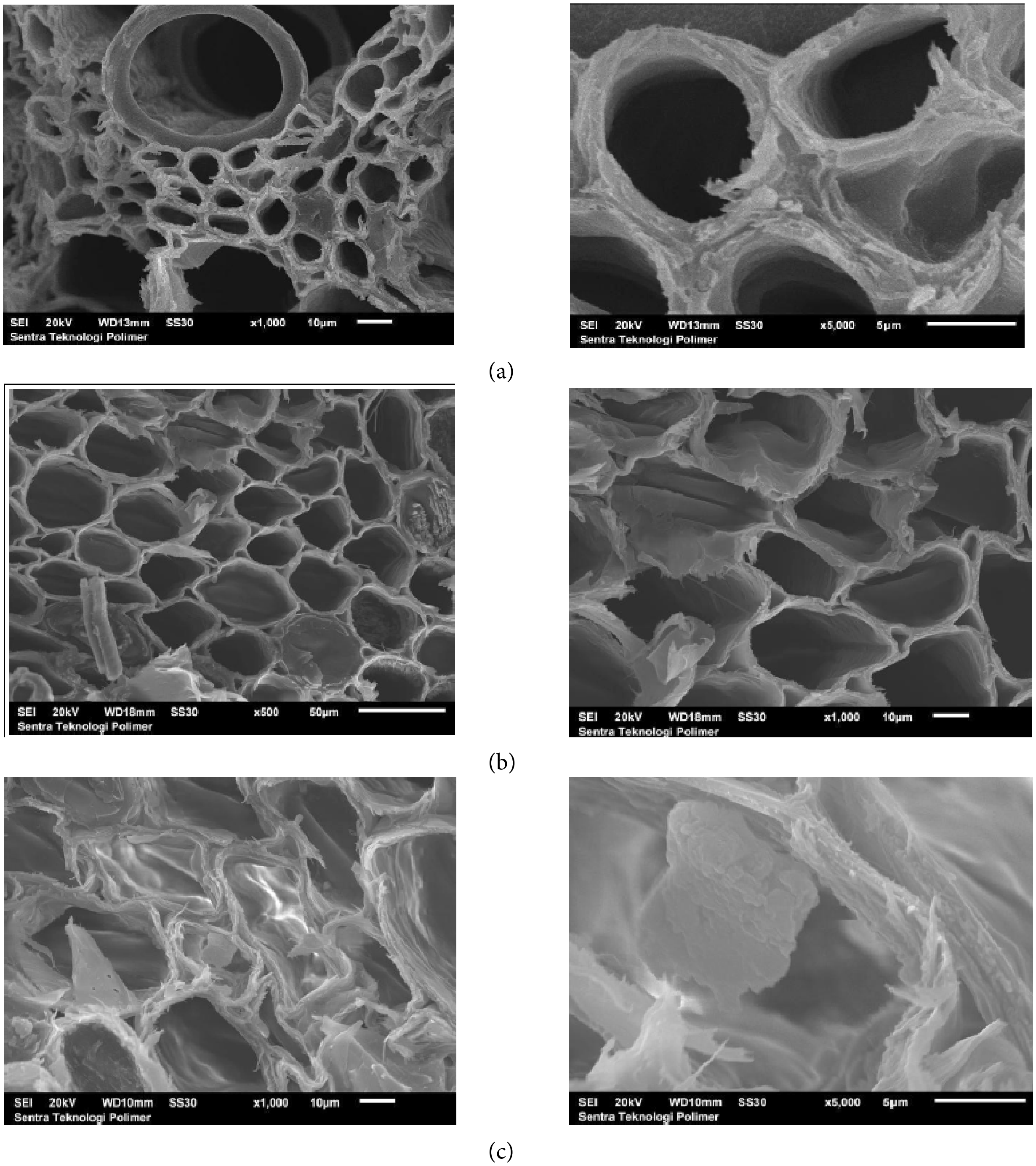

Figure 1. Scanning electron microscopy tensile fracture surface of soybean with 25% of alkali treatment **a)** Compression of surface of using canola with 25 % of alkali treatment **b)** Compression of plain bamboo fibre without matrix and alkali treatment.

sile strength. The soybean has reached its highest bending strength which is 105.98 with the treatment of 25% (v/v) of alkali as can be seen in Table 5.

This can be some defects at the surface or inhomogeneous surfaces. Because in common bending strengths are higher than tensile strengths for the same material as depicted on Figure 1.

Table 5. Alkilation treatment to composite Bending strength

Type of Oil	Alkylation (%)	Bending Strength
		[Mpa]
Soybean	0	20.46
Soybean	5	NI

Soybean	10	95.84
Soybean	25	105.98
Canola	0	28.87
Canola	5	90.99
Canola	10	105.05
Canola	25	57.08

*NI: not identified

4. Conclusion

The mechanical properties of bio-composites are influenced by matrix of the composite, volume fraction of fibre, typed of epoxide vegetables based resins, and concentration of Alkali. It is found the alkali treatment for soybean and canola based resin is much effected to the good mechanical properties of the composite. Conversely may happen to other kind of vegetables oil. The Alkali treatment may caused to the inhomogenity of fibre surface which effected to its mechanical properties.The alkali concentration recommended for the fibre surface modification is 5% (v/v) for epoxide soybean based resin and 10% (v/v) for epoxide canola based resin.

5. Acknowledgement

The author gratefully acknowledges the support of the Indonesia Ministry of Research and Technology, Department of Higher Education as funding the research

6. References

1. Liu XQ, Huang W, Jiang YH, Zhu J, Zhang CZ. Preparation of a biobased epoxy with comparable properties to those petroleum counterparts. Express Polymer Letters. 2012; 6(4):293–8. Crossref.
2. Firdaus FE. An environmental friendly material: epoxide-based resin from vegetables oil for biofiber reinforced composite. International Journal of Applied Research. 2016; 11(7):5152–5.
3. Miyagawa H, Mohanty AK, Burgueno R, Drzal LT, Misra M. Novel biobased resins from blends of functionalized soybean oil and unsaturated polyester resin. Journal of Polymer Science B. 2007; 45(6):698–704. Crossref.
4. Kumar JR, Jindal UC. Mechanical behaviour of bamboo and bamboo composite. Journal of Materials Science. 1992; 27(17):4598–604. Crossref.
5. Saheb ND, Jog JP. Natural fibre polymer composites: A review. Advances in Polymer Technology. 1999; 18(18):351–63. Crossref.
6. Wambua P, Ivens J, Verpoest I. Natural fibres: Can they replace glass in fibre reinforced plastics? Composite Science and Technology. 2003; 63(9):1259–64. Crossref.
7. The State of the worlds's forest genetic resources country report Indonesia. FAO Report; 2011.
8. Firdaus FE. An environmental friendly material: epoxide-based resin from vegetables oil for bio-fiber reinforced composites. International Journal of Applied Research. 2016; 11(7):5152–5.
9. Mohanty AK, Misra M, Drzal LT. Sustainable bio-composites from renewable resources: Opportunities and challenges in the green materials world. Journal of Polymer and Environment. 2002; 10(1):19–26. Crossref.
10. Corradini E, Morais LC, Rossa MF, Mazzetto SE, Mattoso LH, Agnelli JAM. A Preliminary study for the use of natural fibres as reinforcement in starch glutten-glycerol matrix. Macromolecules Symposia. 2006; 245(1):558–64. Crossref.
11. Goud G, Rao. Effect of fibre content and alkali treatment on mechanical properties of roystonea regia reinforced epoxy partially biodegradable composites. Bulletin of Materials Sciences. 2011; 34(7):1575–81. Crossref.
12. Yan L, Yiu Wing M, Lin Y. Sisal fiber and its composites: a review of recent developments. Composite Science and Technology. 2000; 60(11):2037–55. Crossref.
13. Mohanty AK, Misra M, Drzal LT. Surface modification of natural fibres and performance of the resulting biocomposite: An overview. Composite Interface. 2001; 8(5):313–43.
14. Pradad SV, Pavithran C, Rohatgi PK. Alkali treatment of coir fibres for coir- polyester composites. Journal of Materials Science. 1983; 18(5):1443–54. Crossref.
15. Kannan R, Megat MMH. A review on mechanical properties of bamboo fibre reinforced polymer composite. Australian Journal of Basic and Applied Sciences. 2013; 2(8):247–53.