

Production of Tailored Reinforcement of Rattan Fiber Composite

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Abstract

The growing demand of composite for variety applications are facing the depletion of petroleum resources, had made many researchers focuses on using natural materials. Rattan as one of them, are prepared in a woven tailored to reinforced epoxy based matrix, this aimed to partially reduce the synthetics. The fibers are previously conducted in alkali to optimize the cohesiveness of fibers into the matrix. The synergistic effect of adhesives silane and dimethylethanolamine (DMEA) into rattan woven can be boosted on shortening the curing time which results to an ultimate property of composite and reduces the production cost. The porosity and a hydroxyl content of fibers are might be obstacles to the series process which can be affected to the failures of maximizing the toughness of the product. The proper treatment can solve these problems.

Keywords

Production, rattan reinforcement, ultimate property, composite

1. Introduction

Composites can be used in a wide variety of applications not only for electricity, thermal, environment, and many others. Composites are a combination of two materials, one served a reinforcer in the form of fibers, sheets, or granules which are transmitted into the matrix phase. The reinforcer conducted a load carrier is stronger than the matrix. The matrix served a load transfer medium between fiber to protect fiber from environmental damages, but if properly designed it will show better strength material.

Fiber-matrix adhesion is a condition to make sure the property of good composite can be maintained in maximum stress level across the interface. If the adhesion is under the optimum the load has to be reduced. Surface treatment or coating is a way to increasing fiber-matrix adhesion. Silane is used on finishes of glass fibers [1], and rattan fiber for improving fiber-matrix adhesion [2]. It was applied to be used to fiber surface after being coated a resin. Using the natural fiber for the composite fabrication there are several advantages besides its cheap production cost it also has better mechanical properties [3]. The uniqueness is its porous fiber enabling on absorbing moisture which comprehensively impacted to properties of composite [4].

2. Literature Review

Using the natural material as so-called lignocellulose fibers the reinforced matrix, with numerous advantages. The uniqueness of natural fiber is its low density and low specific weight can result in high strength and stiffness [5-7]. The natural fibers embedded in the polymer matrix can increase crystallinity, heat resistance, stiffness, and enable to replaced the expensive matrix in certain percentages into very low cost owing to its multiple advantages [8].

The drawback of using fiber as a filler for the matrix is the low processing temperature due to the possibility of fiber degradation which comprehensively could affect the composite properties [9].

The rattan based composites are the used for replacement of wood-plastic composites which dominated at the present. The addition of fillers to epoxy generally gives a positive effect to the mechanical properties. The combination of fillers and epoxy, both are exhibit polar forces so it resulted in tremendous adhesion between filler and matrix. This due to the polar forces activates the reactive sites of resin and fiber surface. The (- OH) groups of the epoxy resin can form strong polar attractions to hydroxyl surfaces. If compared to the surface of metals, minerals, glasses, ceramics, and etc as a group of inorganics they have a polarity with high surface energy, otherwise, the fibers are generally less polar another word more covalent with low surface energy. The poor dispersion and insufficient reinforcement will lead to fabricate poor mechanical properties of the composite.

The solution on adding silane as a coupling agent, DMEA [2], and doing a chemical modification on natural filler [10-14], is to provide an enhancement of interfacial adhesion between filler and matrix [15].

As the group of a palm tree, rattan grows throughout tropical forests. The fact of dissimilar polarity structure between rattan fiber and the binder, the fibers are previously treated by proper alkylation concentration to minimize the interfacial tension.

This research has been carried out of producing composite using rattan fiber and the epoxy matrix. The goals of this research are to find the best condition of fabricating to the ultimate mechanical property of rattan based composite.

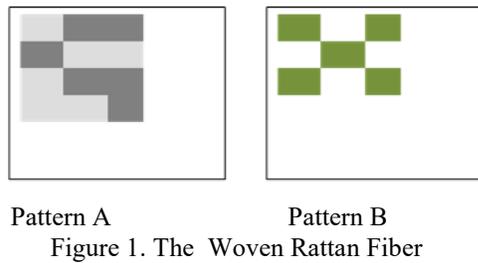
3. Methodology

3.1 Sample Preparation

Silane is supplied by Merck, dimethylethanolamine (DMEA), NaOH, synthetic epoxy resin, and blending of synthetic epoxy resin and edible epoxide. The rattan fiber was purchased from rattan traders in East Jakarta area. The fiber is cleaned with the cut until it reaches 0.2 cm of thickness. The ability of lignocellulosic of rattan to absorb moisture must be considered when composites developed because increased moisture content much affected to the dimensional stability of the composite. Following to previous research founding, the moisture will cause to mold formation on rattan fiber. The alkali treatment is a way solved and could enhance the interfacial bonding. Anyway in several sources of research finding the alkali treatment is still much questioned of the declined strength of the fiber. The proper concentration of alkali fabricates thermally stable composites. Rattan fibers are previously tested to measure the compatibility to epoxy resins. The composite product then prepared to be tested for several mechanical tests. Each of the tests is done in two categories, which are: immersed in water and without water immersion after alkalization step.

3.2 Rattan Fiber Preparation:

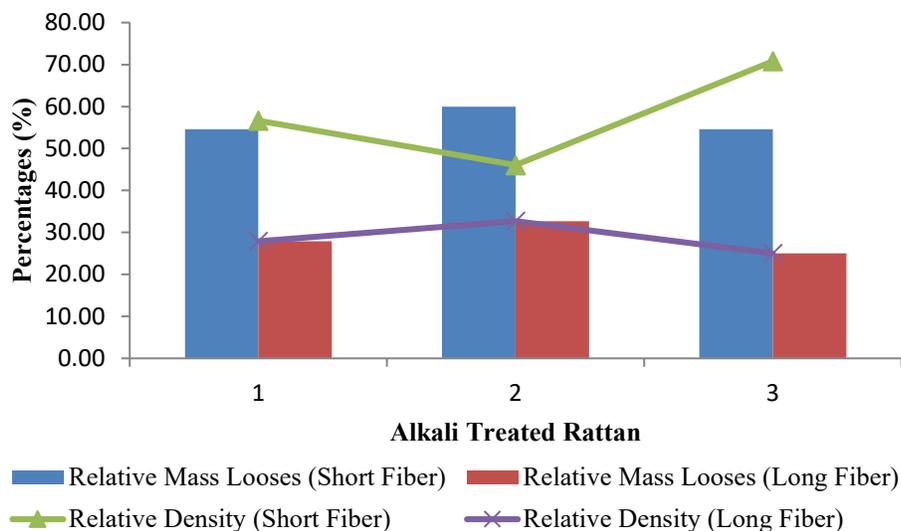
Rattan fiber is prepared, the cut of short fiber with dimension of 1 cm x 1 cm x 0.2 cm and long fiber is 1cm x 15 cm x 0.2 cm. The short fibers are used as a control variable to alkylation response. The long fibers are made woven with the predetermined patterns. Basic pattern selection is to know the strength of composite rattan with different patterns. The rattan fibers are previously treated by 5% alkylation, clean washed with running water, dried for 36 hours in the oven with temperature 300C. Pattern A is more complicated in terms of bonding than pattern B as illustrated in figure 1. The resin prepared into; synthetic based, and blending synthetic epoxide to corn epoxide.



4.Result and Discussion

4.1.Relative Density

The alkali treatment over rattan fiber has caused to relative mass losses and relative density value as illustrated in Figure 2. The cross-sectional area of short fiber seems to lose more than the long fibers, besides the appearance of short fiber is brittle after being immersed in alkali, so it is doubtful to be used as a matrix reinforcer. In this study, it was decided to use long fiber.



Figures 2. The Rattan dimension to relative mass losses and relative density

4.2.Flexural Test

The composite is conducted by running a flexural test. This test is often referred to as modulus of rupture or bending strength. This test is included in the mechanical test, aimed to identify the brittleness of the material. The interaction between adhesives, fiber, and the matrix produces composite strength, which also allows flexible responses. This test is done by comparing the flexural of composite immersed in water immersion in 60 minutes to composite without immersion as a control variable. The flexural of the composite which used silane during fabrications have found in the range of 0.86 to 2.3 (kgf/mm²) while using DMEA is 1.43 to 2.79 (kgf/mm²). The use of DMEA over Silane in composite fabrication provides significant flexural value, as in general the flexural strength of composite previously immersed in water with DMEA addition is higher than without immersion. While the flexural strength of composite without water immersion with Silane addition is higher than if the fiber is being immersed in water.

Table 1. Adding Silane and DMEA to water Immersed Composite to Flexural Strenght

Pattern	Adhesives	Flexural (kgf/mm ²)	
		Water Immersion	Without Immersion
A	Silane	1.71	2.3
B	Silane	0.86	1.05
A	DMEA	2.79	1.43
B	DMEA	1.84	2.53

The use of DMEA in the flexural in pattern-A is 2.79 (kgf/mm²) and the pattern-B yields 1.84 (kgf/mm²) they both are immersed in distilled water for 60 minutes. If compared to the bending modulus of composite DMEA without water immersion are respectively 1.43 (kgf/mm²) pattern-A and 2.53 (kgf/mm²) in pattern-B. The flexural of the complicated woven pattern if applied DMEA without water immersion is stronger than water immersion. The composite with water immersion if applied DMEA during fabrication is stronger than without immersion.

The use of Silane if immersed in water using woven pattern-A is stronger than the pattern-B which are respectively 1.71 (kgf/mm²) and 0.86 (kgf/mm²). The bending modulus of the composite with Silane addition without water immersion in woven pattern-A is 2.3 (kgf/mm²) and woven pattern-B resulted in 1.05 (kgf/mm²) respectively with mean 1.67 (kgf/mm²).

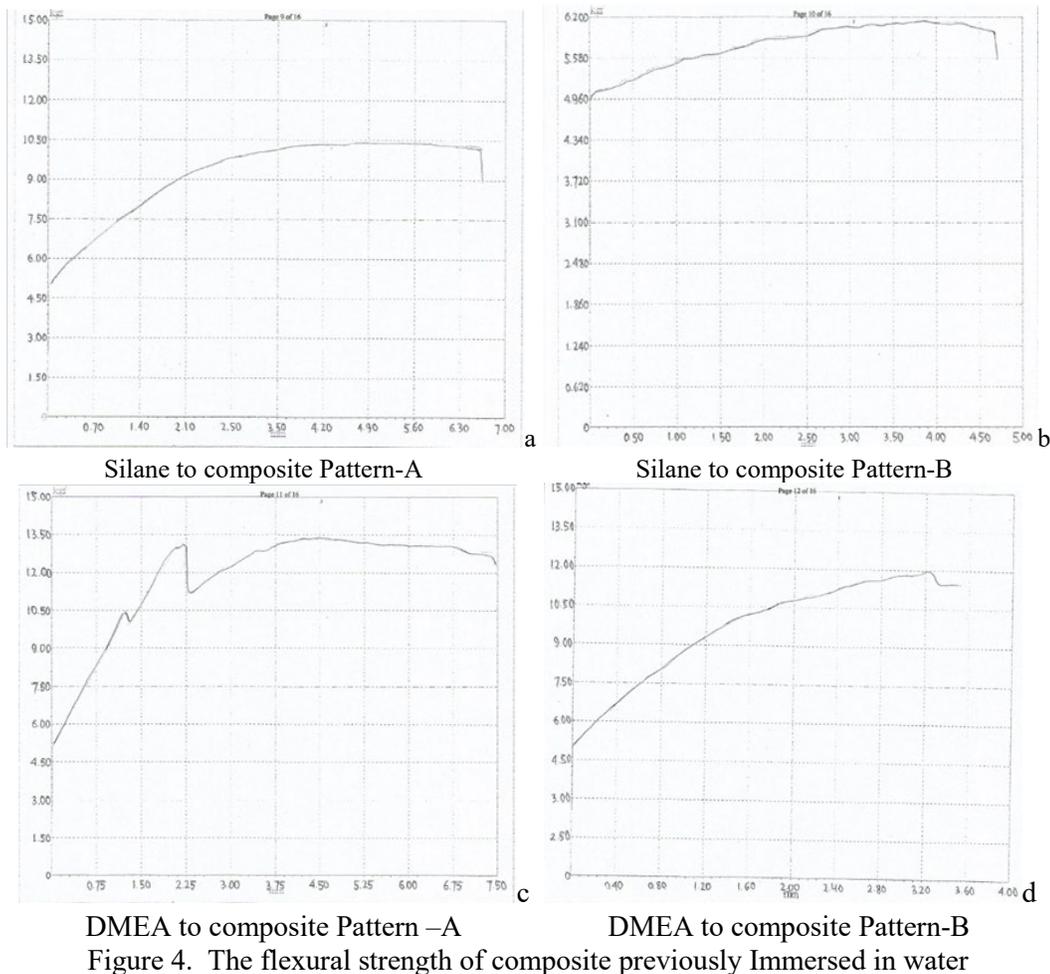


Figure 4. The flexural strength of composite previously Immersed in water

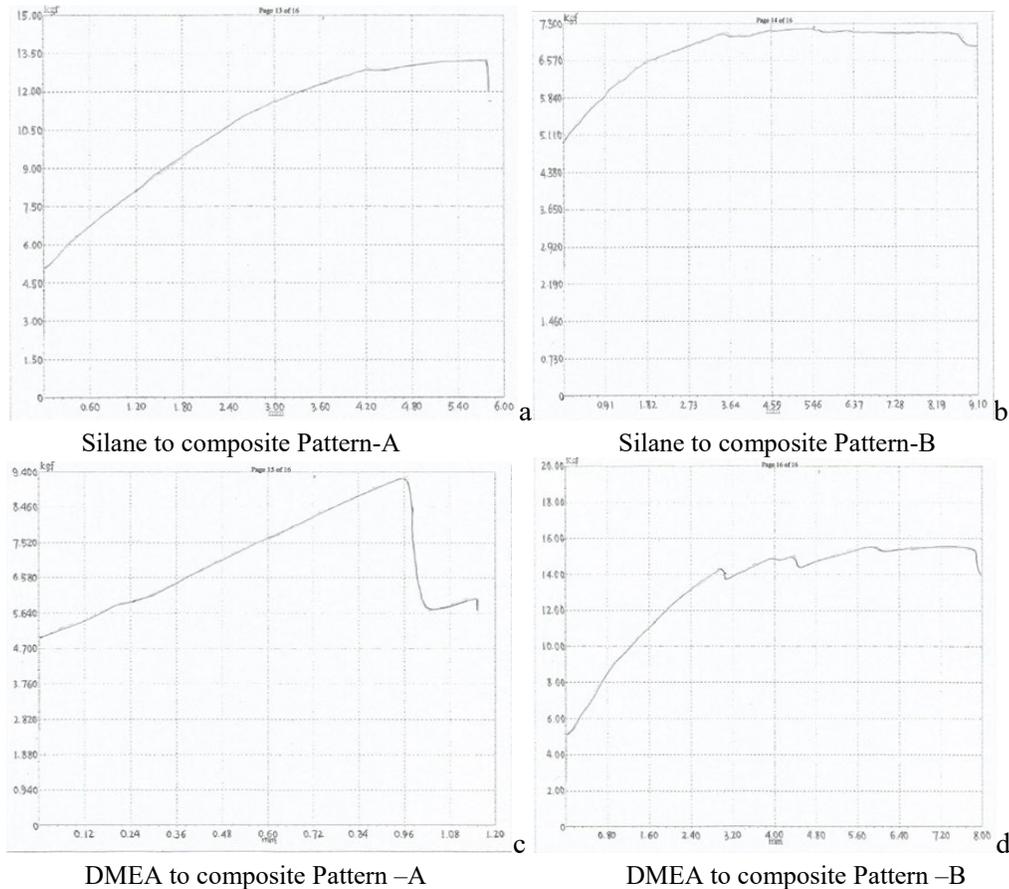


Figure 3. Flexural strength of Composite without water Immersion

From this test the flexural of the composite which previously immersed can be concluded, the flexible modulus is higher using DMEA compared to silane in woven pattern-A, so as happened to woven pattern-B. The same thing happened to composite without water immersion the flexible modulus is higher using DMEA rather than silane. If the woven is more complicated the flexural using silane is higher than DMEA. The curing time of composite using silane is 3 hour while using DMEA the curing time is 6 hours even though the appearance of composite more clear. This took more time if the fabrication of composite is without adhesive booster which is more than 10 hour. Meanwhile if compared to the flexural strength of fiber applied with blending of synthetic epoxy with edible corn epoxide resin is 8.3 kgf/mm^2 , which is higher than synthetic epoxy alone.

4.3.Hardness Test

The test of the composite surface is done with a standard deviation of 0.5. The hardness test is done to homogeneous surface in randomly pattern-B using silane as can be seen in Figure 4.

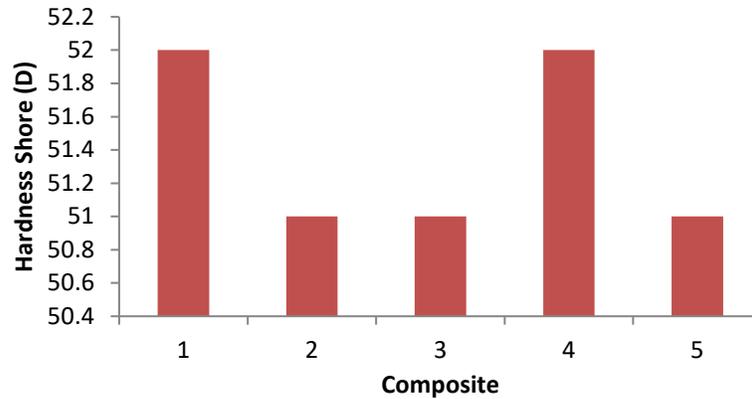


Figure 4. Hardness of composite

4.4 Thermal Test

Thermal test using Perkin Elmer was carried out by Differential Scanning Calorimetry (DSC) 8000 with heating rate is 30^oC / minute with N₂ gas purging (flow rate 20 mL/minute) with scanning 30^oC to 250^oC. Samples with ranging of 7.4 to 8.8 mgr were sealed in an aluminum pan. The crystallization was determined as follows:

$$X_c(\%) = \frac{\Delta H_c}{(1-x)\Delta H_m^0} \times 100\% \quad (1)$$

Where ΔH_c is melting peak area, ΔH_m^0 is melting enthalpy, and x is fiber weight fraction. Epoxy resin will not crystallise which consequently form glassy, amorphous solid which tend to exhibit softening point. Glass transition temperature is affected by: polar, intermolecular forces increase T_g. Polymers with rigid chains are difficult or slow

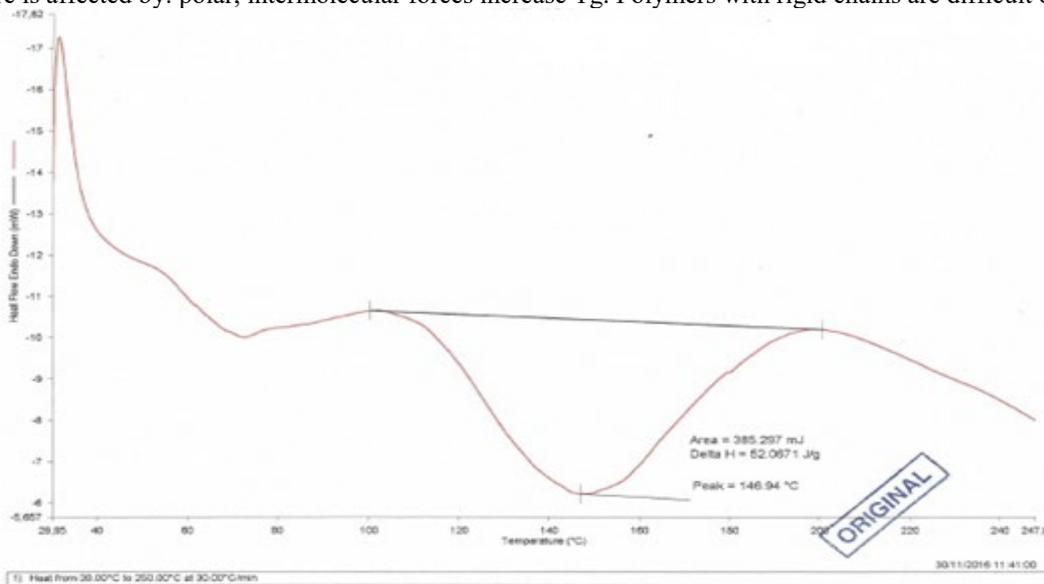


Figure 5. Thermal of Blending synthetic epoxy - corn epoxide

to crystallize, but the portion that does crystallize will have a high T_m. Branches of the lower the glass transition temperature which is a number of end groups. The Glass temperature and the melting temperature of the polymer matrix resulted from observations of corn epoxide, where the fiber previously conducted alkali treatment 10% NaOH. The peak melting temperature is = 146.94 °C as can be seen in figure 5.

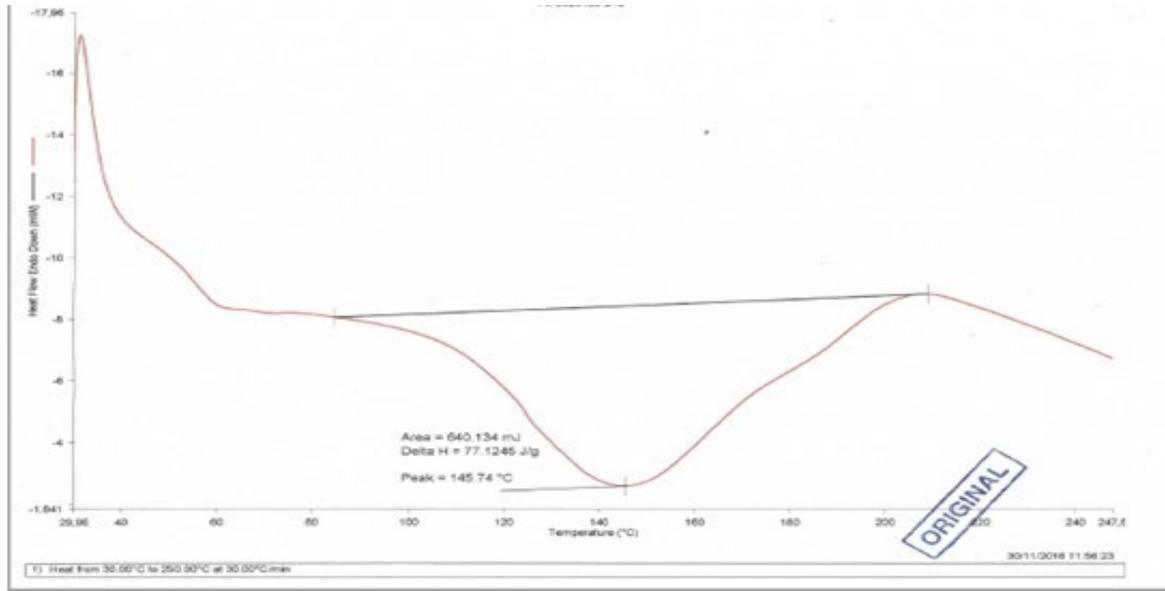


Figure 6. Thermal of Blending synthetic epoxy - sunflower epoxide

The thermal of Blending synthetic epoxy and soybean epoxide, where the fiber is previously treated with 5% alkali as depicted in figure 7.

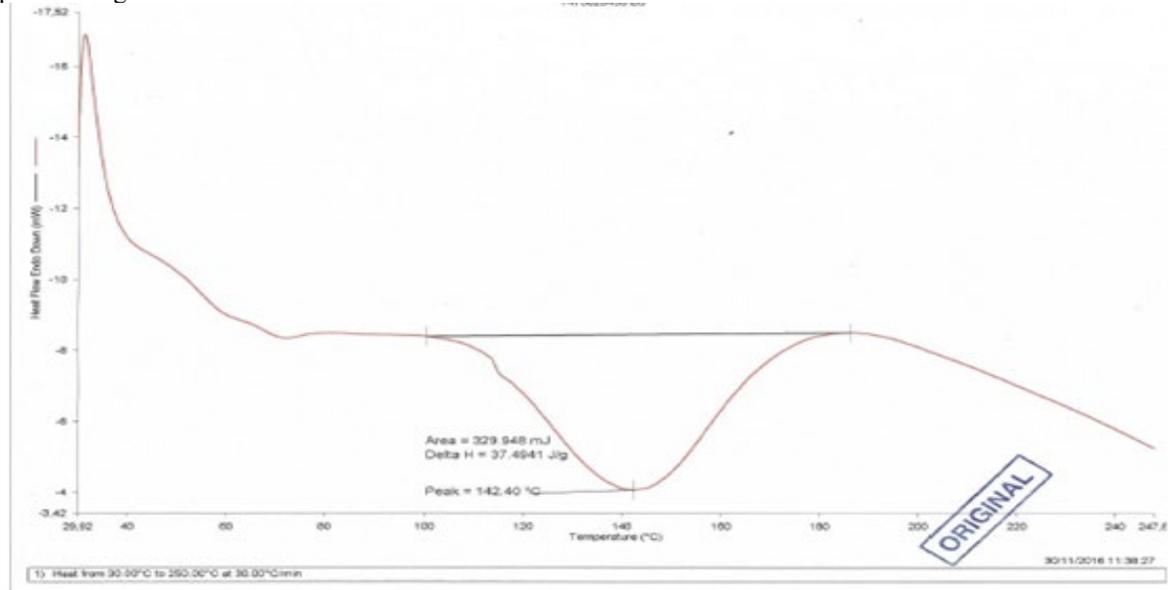


Figure 7. Thermal of Blending synthetic epoxy - soybean epoxide

The result of thermal using DSC is summarized in table 2.

Table 2. Thermal properties of the composite Using thermoset Matrix

Sample	Type of Blending	Alkali (%)	Tm (C)	Tc (C)	ΔT (J/g)	ΔH_m (J/g)	Cristallinity
1	Synthetic epoxide+corn epoxide	10	146.94	30	116.94	-17.2	11.86
2	Synthetic epoxide+sunflower epoxide	25	145.74	32	113.74	-17.2	5.7
3	Synthetic epoxide+ soy epoxide	5	142.4	31	111.4	-17	5.3

The results above when compared to the synthetic epoxy alone for thermal test the melting temperature is 64.39. If it is associated with the cost production of using natural fibers with the ranging of fraction weight is 23.69 to 42.77 from the total composite, it is much cheaper than a synthetics. Using matrix comprises a blending of synthetic epoxide with edibles epoxide to natural fiber with the assumption the fraction weight is same with above, the production costs will be more reduced. If the synthetic epoxide is still decided to be the matrix to reach the composite strength, using silane can be considered to be put in the formula for composite fabrication because the production time is shorter than DMEA so it will reduce production costs.

Conclusion

Some considerations on making composites from rattan fiber naturally have relatively high levels of water content the process of dispersing fibers in the matrix will not be effective. Thus giving dimension instability of the final product. Natural fibers are generally hydrophilic so are not compatible with the most matrix. To increase the wetting ability of fibers the surface needs to be modified so it becomes hydrophobic. Adding adhesive booster to the formula is much reduce the production cost because the curing time has reached the short time of production. This study has recommended on using Silane in the composite fabrication if using rattan fiber.

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