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EVALUATION OF MECHANICAL PROPERTIES OF COIR-*ANGUSTIFOLIA HAW* AGAVE FIBER REINFORCED HYBRID EPOXY COMPOSITE

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ABSTRACT: Evaluation of Mechanical Properties of Coir-*angustifolia Haw* Agave Fiber Reinforced Hybrid Epoxy Composite This article presents the mechanical properties of coir-*angustifolia Haw*agave fiber hybrid composite. Prior to form composite, these fibers were soaked in 5%w/v NaOH solution during 24 hours. Coir fibers were twisted and composed one direction like mat and agave fibers were also composed one direction and formed mat. Epoxy resin was used as matrix in this hybrid composite.The hybrid composites were manufactured using hand layup technique followed by compression molding. The variation of fraction volume of coir fiber and agave fiber was 10:20, 15:15 and 20:10 respectively. The tensile strength, tensile modulus, flexural strength and flexural modulus were evaluated. Fracture tensile was analysed by Scanning Electronic Microscopy (SEM). Result showed that 15%Vf coir and 15% Vf agave fibers on the hybrid composite yield high tensile strength, tensile modulus and flexural modulus compared to other fraction volume. SEM analysis exhibits that all fraction volume variations on the composite tend to undergo fiber fracture without pull-out and matrix damage.
Keywords : hybrid composite, coir fiber, angustifolia Haw agave fiber, matrix, mechanical properties.

ABSTRAK : Evaluasi Sifat Mekanis Komposit Epoksi Hybrid yang Diperkuat Serat Sabut Kelapa – Serat Agave Angustifolia Haw. Artikel ini menjelaskan sifat mekanis komposit hibrid yang diperkuat serat sabut kelapa-serat *angustifolia Haw*agave. Sebelum komposit dibentuk serat tersebut direndam dalam larutan 5%w/v NaOHselama 24 jam. Seratsabut kelapa dipelintir dan disusun satu arah dan membentuk mat dan serat agave juga disusun dalam satu arah dan juga dibaut dalam bentuk mat. Matrik yang digunakan adalah epoksi resin. Komposit hibrid di buat dengan metode hand layup diikuti dengan penekanan pada cetakan. Variasi volume fraksi serat sabut kelapa dan serat agave adalah 10:20, 15:15 dan 20:10 secara berturut-turut. Kekuatan tarik, modulus tarik, kekuatan lentur dan modulus lentur telah dievaluasi dalam artikel ini. Patahan akibat uji tarik dianalisis dengan menggunakan Scanning Electronic Microscopy (SEM). Hasil penelitian menunjukkan bahwa kandungan serat kelapa 15% dan serat agave 15% dalam komposit hibrid menghasilkan kekuatan dan modulus tarik serta modulus lentur yang lebih tinggi dibanding dengan kandungan serat lainnya dalam komposit hibrid. Hasil analisis SEM juga menunjukkan bahwa kecendrungan semua variasi kandungan serat (volume frakasi) mengalami patahan serat tanpa pull-out dan kerusakan pada matrik.
Kata kunci: hybrid composite, coir fiber, angustifolia Haw agave fiber, matrix, mechanical properties.

INTRODUCTION

The development of material eco-friendly has provided opportunity to utilize natural resources like natural fiber as reinforcement of composite materials. Natural fiber composite has been used in the manufacture of automotive interior and furniture. Utilization of natural fiber like jute, coir, hemp, agave as reinforcement of composite due to abundant, cheap, biodegradable, lightweight, higher toughness and renewable (Rafiquzzaman et al., 2016).

Natural fibers like coir and *angustifolia Haw*agave fibers have been developed as reinforcement of composite. Mechanical properties of coir fiber have been investigated by Kulkarni et al., (1981) and Bakri and Eichhorn, (2010). Their results showed that tensile strength of coir fiber is low but elongation is higher than other natural fibers.Tensile and modulus strengths of *angustifolia Haw*agave fiber have been reported by Silva-Santos et al., (2009). Their tensile and modulus have higher than coir fiber.
Some studies of coir fiber composite with different of matrix has been conducted by

Prasad et al., (1983) and Monteiro et al., (2008) using polyester, by Harish et al., (2009) using epoxy and by Wambua et al., (2003) using polypropylene as matrix. Meanwhile, agave fiber as reinforcement of composite was studied by Bakri et al., (2012) where variation of fiber length influenced to tensile strength and flexural strength.

Hybrid composite is a combination of two or more fibers in a matrix. The natural fiber hybrid composites have been investigated by some researchers. Kakou et al., (2015)reported that coir and palm fibers hybridization using high-density polyethylene (HDPE) matrix hasintermediate value of mechanical properties for each fiber with non-hybrid composite of coir fiber and palm fiber.Islam et al., (2015) evaluated hybrid nanocomposite using kenaf and coir fibers as reinforcement and montmorillonite combined. Hybridization fibers and montmorillonite incorporated increased mechanical properties of composite. Then, mechanical properties of sisal/coir fiber hybrid composite using epoxy as matrix studied byAkash et al., (2016)where tensile and flexural strengths of 40%wt coir and sisal fiber have higher than other fiber content.

In this paper, coir fiber and agave fiber were combined as reinforcement in epoxy composite. Tensile, flexural and impact properties were evaluated. Tensile fracture was analyzed using Scanning Electron Microscopy (SEM).

METHODOLOGY

Materials and Methods

Coir fibers are extracted from husk of coconut, and agave fibers are extracted from agave leaves. Then, these fibers are soaked in 5%w/v NaOH solution during 24 hours. Coir fibers are manually twisted and then twisted fibers are made as coir fiber mat(Bakri et al., 2015). Meanwhile, agave fibers are composed like mat. Epoxy are used as a matrix and these polymers were purchased from local market.

Fabrication of hybrid composite

Hybrid composite of coir fiber mat and agave fiber mat is molded with hand layup process using a steel plate mold. It is fabricated with 30% fraction volume of fibers (Table 1). The position of coir fiber mat and agave fiber mat is shown in Figure 1. Agave fiber mat is as a skin and coir fiber mat as core.

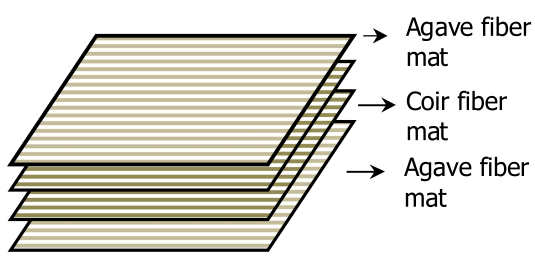

Figure 1. Coir/agave hybrid composite

Table 1. Composition of hybrid composite

Symbol	V_f (%)		V_m(%)
	Coir	Agave	Epoxy
10C20A-E	10	20	70
15C15A-E	15	15	70
20C10A-E	20	10	70

A: Agave, C: Coir, E: Epoxy

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Mechanical Properties Evaluation and Fractography of Tensile

Mechanical behavior of hybrid composites were examined including tensile, flexural and impact strengths. Tensile test was carried out using Universal Testing Machine with the ASTM 638-02 standard. The flexural test (three-point bend) was carried out according to ASTM D 790-02 standard. Then, impact testing was performed based on the ASTM. The fracture of tensile testing was observed using Scanning Electron Microscope (SEM)

RESULTS AND DISCUSSIONS

Evaluation of mechanical properties of hybrid composite with coir fiber mat and agave fiber mat as reinforcement in this result including tensile strength, tensile modulus, flexural strength and flexural modulus. To understand these properties, tensile and flexural testing were performed. The value of mechanical properties of coir-agave fiber mat hybrid composite can been seen in Table 2.

The coir-agave fiber mat reinforced hybrid composite exhibit different value of tensile strength (Figure 2) and tensile modulus (Figure 3) related to variation of fiber content in the composite. Experimental result of tensile strength of hybrid composite in Figure 2 shows that volume fraction of coir fiber and agave fiber influenced tensile strength where 15% V_f coir dan 15%V_f agave (15C15A-E) has higher tensile strength than other samples. Meanwhile, tensile modulus behavior of this hybrid composite in Figure 3 exhibits that 15C15A-E sample is also higher tensile modulus than 10C20A-E and 20C10A-E samples i.e. 329.75 MPa. This indicate that proportional fiber in composite between coir and agave fibers may improve tensile strength and tensile modulus of hybrid composite.

Tabel 2. Mechanical properties of coir-agave fiber mat reinforced hybrid composite

Symbol	Tensile Strength (MPa)	Tensile Modulus (MPa)	Flexural Strength (MPa)	Flexural Modulus (GPa)
10C20A-E	46.48	306.30	67.04	4.84
15C15A-E	48.37	329.75	80.53	4.98
20C10A-E	40.01	293.38	87.20	4.90

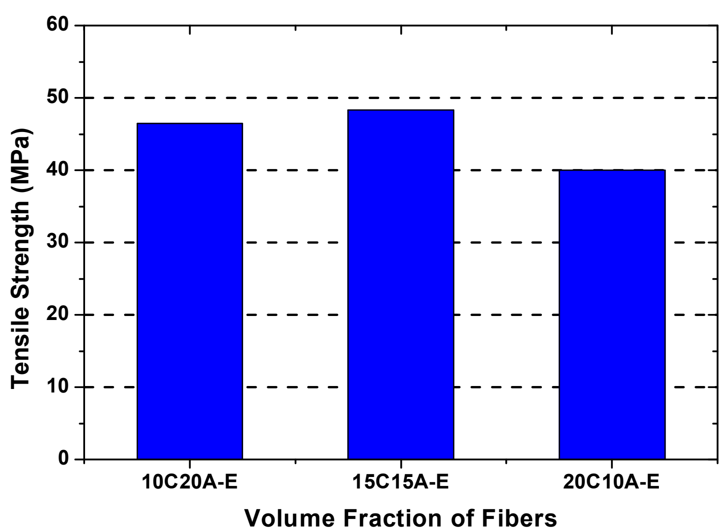

Figure2. Tensile strength of hybrid composite

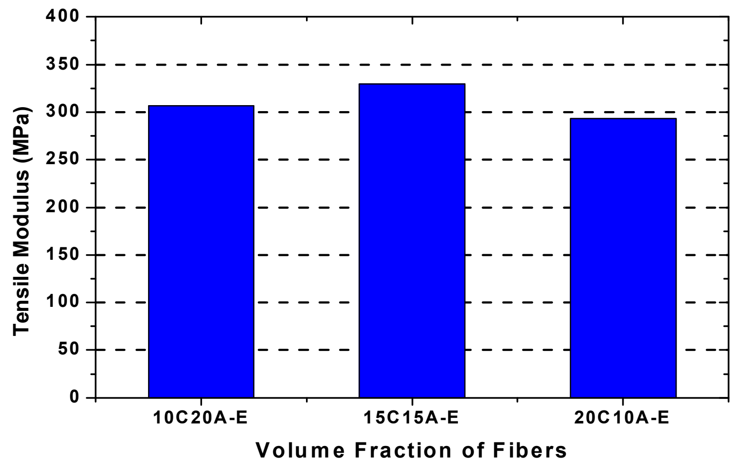

Figure 3. Tensile modulus of hybrid composite

The flexural strength of hybrid composite related to volume fraction of fibers is shown in Figure 4. The result exhibits that hybrid composite withmore content of coir fiber has higher flexural strength than less content of coir fiber. The flexural strength of 20C10A-E is 87.20MPa. 20C10A-Esample has 20% V_f coir fiber and 10%V_f agave fiber. It means that content of coir fiber in the composite is more than agave fiber. Agave fiber has high mechanical properties compared to mechanical properties of coir fiber. Agave fibershould support low mechanical properties of coir fiber so that more content of coir fiber and less content of agave fiber should be low strength of composite. But, in this case flexural strength in less content agave and more content of coir fiber occurs inversely. One reason may be due to coir fiber used in twistedfiber mat so that it can increase flexural strength of composite. Then, Figure 5 shows relation between flexural modulus and variation of volume fraction of fibers. As can been in Figure 5, flexural modulus is not change significantly on change of volume fraction of coir fiber and agave fiber in the composite.

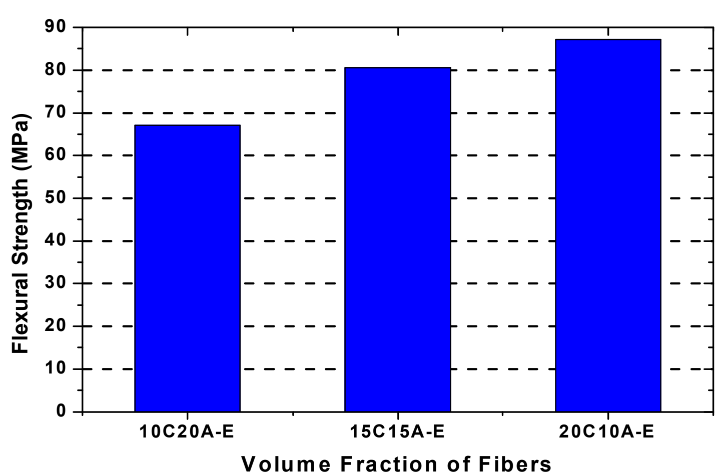

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Figure 4. Flexural strength of hybrid composite

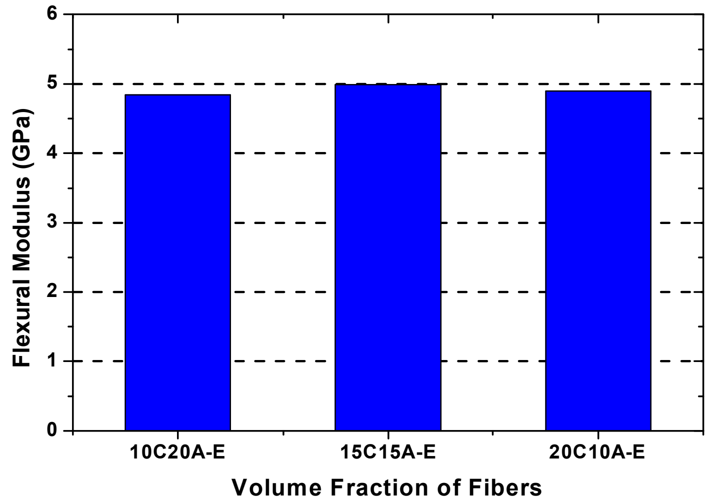
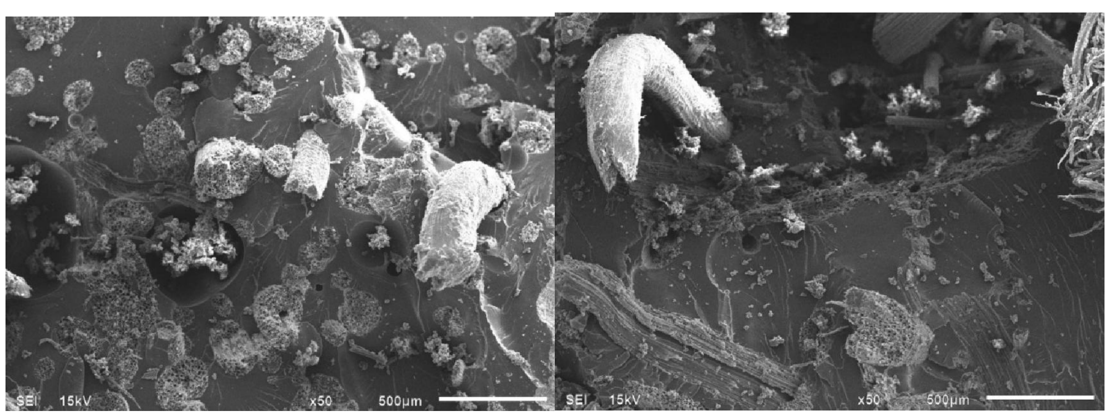


Figure 5. Flexural modulus of hybrid composite

Tensile fracture evaluation of coir-agave fiber reinforced hybrid composite can been seen Figure 6. Good adhesion, pull out fiber from matrix and cut-off fiber as well as matrix damage appear in the SEM image after tensile.

Figure 5 (a) exhibits that fibers tend to cut off but not pull out from matrix and also voids appear on matrix surface which can decrease strength of composite. Fiber shear, cut off fiber from matrix and damage matrix can also be seen in Figure 5 (b). Then, in the Figure 5 (c) fibers tend to fracture and matrix breakage is also existence which influences composite performance. Based on result of tensile testing, 15%V_f coir and 15% V_f agave on the composite has good strength compared to other content of fibers due to good adhesion fiber/matrix (less damage matrix).



(a) (b)

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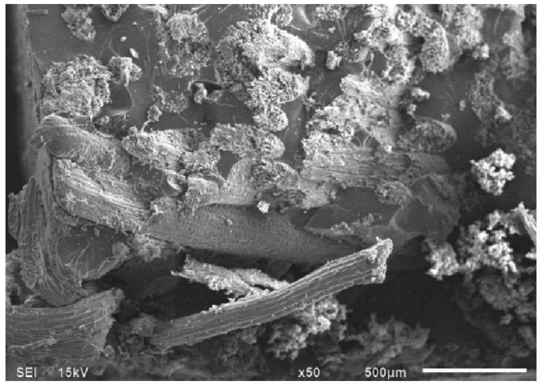

(c)

Figure 6. SEM of coir and agave fibers hybrid composite tensile fracture (a) 10C20A-E (b) 15C15A-E (c) 20C10A-E of

CONCLUSIONS

Mechanical properties of coir-*angustifolia Haw* agave fiber reinforced hybrid composite were evaluated. The result showed that hybrid composite with fraction volume of 15% coir fiber and 15% agave fiber has higher tensile strength and tensile modulus as well as flexural modulus than other fraction volume. The different value of tensile strenght and tensile modulus was supported by SEM analysis where hybrid composite undergo fiber fracture without pull-out and matrix damage.

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