New biocomposite material from ramie fibre and natural matrix of flee secretion on albasia tree as expansion effort of teaching material

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Abstract : *A biocomposite is a composite which consists of natural fiber as reinforcement and matrix as binder agents. Biocomposite materials are interesting phenomena because they are environmentally friendly, are renewable resources, and can increase the economic level of the neighbouring people. The objective of the present study is to look into the feasibility of biocomposite material from secretion of albasia flea as a binder agent and ramie fiber as reinforcement. Secretion of albasia flea was collected from Ciamis forest, West Java, Indonesia with lumps type and then was reacted with methylated spiritus to liquefaction. Heating of the dilution of flea secretion at 180°C in 15 minutes decreased the viscosity to become gel. The gels were layered on the surface of ramie fiber woven roving with the hand layout method. Molding of the biocomposite was done at 180-200°C in 10 minutes after 2-4 layers of ramie fiber were soaked with gel, pressing with pressure 40 MPa, and cooling at room temperature in 4 hours. Density and tensile strengths of the biocomposite were evaluated with ASTM D638-90 standard and compared with publicized biocomposites to know its feasibility. The tensile strength of the biocomposite from 60% of ramie fiber woven roving and secretion of albasia flea was 80 MPa with a density of 1.17 g/cm^3. This result showed that the biocomposite had a relatively higher tensile strength and lower density than an epoxy or polyester matrix. The biocomposite of the matrix of albasia flea secretion can become a novel material, have high feasibility based on availability of renewable resources, give simplicity of matrix processing, need no high technology on molding biocomposite, and have higher tensile strength relative to lower density. An implication of the results of the study can be in the development of new teaching material in the engineering material subject of study in the Faculty of Engineering of Yogyakarta State University.*

Keywords: *biocomposite, ramie fiber, secretion of albasia flea, natural matrix, tensile strength, density, binder agent, reinforcement*

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1. Introduction

A biocomposite is a composite which consists of natural fiber as a reinforcement and natural matrix or synthetic polymer as a binder agent. Biocomposite materials are interesting phenomena because they are environmentally friendly, are renewable resources, and can increase the economic level of the neighbouring people especially in Indonesia. The Indonesian climate and soil can grow various kinds of natural fiber such as ramie, pineapple, *lontar, pandan, saeh*, bamboo, etc. Ramie fibers are one of the abundant natural fibers in Indonesia. Ramie trees (*Boehmeria nivea*) have been successfully cultivated for almost 300 hectares by the cooperative of *Pondok Pesantren Darussalam (Kopontren Darussalam)*, Garut, West Java.

Ramie trees grow at a height of 0 -1500 m above sea level which have loose soil or clay sand containing a lot of organic substance and having pH between 5-6 and rainfall 1200-2000 mm/year. The production of ramie trees lasts 6 - 20 years with a period of 50-60 day crop and produce 2.5 tons of ramie plant per hectare. Ramie trees have close plants and deep root so that they can prevent erosion and floods. Recently, ramie fibers are used in the textile area at the price of Rp 300/kg as wet ramie plant and Rp 9.000/kg as ramie fibers.

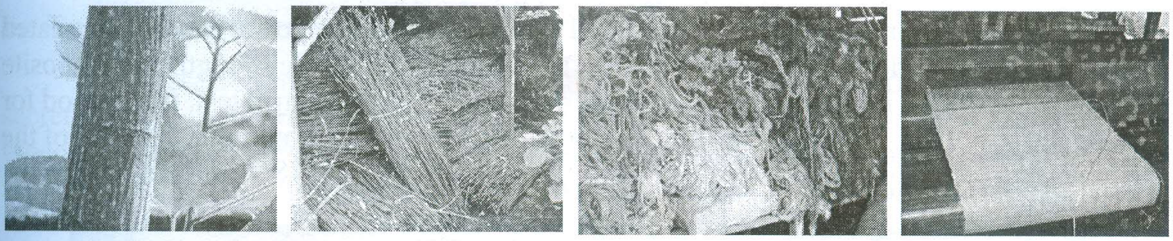
The properties of ramie fibers have been investigated by Munawar *et. al.* (2006) showing that the fibers have a tensile strength of 849 MPa, a modulus young of 28,4 GPa, a tougness of16 MPa, and a density of 1,38 g/cm^3. Ramie fibers have very good mechanical properties compared to other publicized natural fibers such as flax 500-900 MPa, sisal 80-840 MPa, jute 200-450 MPa, hemp 310-750 MPa, banana 530-750 MPa, coir 130-175 MPa, and cotton 300-600 MPa (George *et al.*, 1999; Saeb *et al.*, 1999, Mohanty *et al.*, 2000; material of database www.matls.com). Abundant availability, good mechanical properties, and limited usage of ramie fibers become the motivation for the researcher to develop them as a biocomposite material.

Development of natural polymer as a composite matrix has been increasing rapidly in the world such as chitosan, soybean, casein, cassava, maizena, albumin, or collagen of skin and animal bone. Chitosan is one biopolymer from crustacean skins like prawn, crab, cockle, and shellfish being developed in Japan as a natural matrix (Umemura, 2006). In Indonesia, people of Ciamis District, West Java have been using natural polymer from secretion of albasia flea to adhere the traditional dagger with its handle from buffalo horns. According to these people, secretions of albasia flea have more adhesive power than Alteco glue. Secretion of albasia flea is traditionally called ant house by the local people. Secretion of albasia flea has the shape of small blocks which can be liquefied and re-solidificated through mixing with volatile solvents such as alcohol, methylated spirit, or methanol. The main reasons for developing natural matrixes from secretion of albasia flea were high its adhesive power and its ease in cultivation. The objective of the present study is to develop a biocomposite which consists of ramie fibers as a reinforcement and natural matrix from secretion of albasia flea as a binder. The biocomposite is a new material which is produced from all natural and local resources.

2. Materials and Method

a. Materials

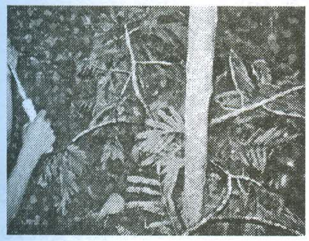
Ramie fibers were taken from one of the biggest ramie crop plantation in Indonesia belonging to the co-operative of *Pondok Pesantren Darussalam*, Garut, West Java. The fibers were taken from a crop bar of 2 months of ramie plant, peeled off the outer skin, washed them with water, took off the fibers, and then weaved by woven roving type 0/90° (Fig.I).



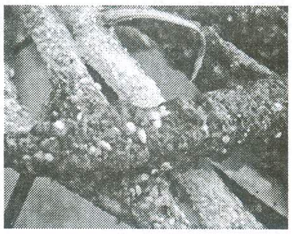
(a) (b) (c) (d)

Figure I: Ramie fiber processing: (a) Ramie plant, (b) ramie crop bar, (c) Ramie fibers, (d) Ramie fiber woven.

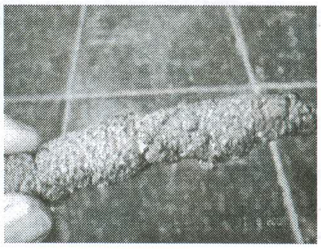
The natural matrix the for binder biocomposite was secretion of albasia flea taken from Ciamis District, West Java, Indonesia. Secretions of flea were separated from albasia crotches and collected with lump types in irregular shapes (Fig. II).



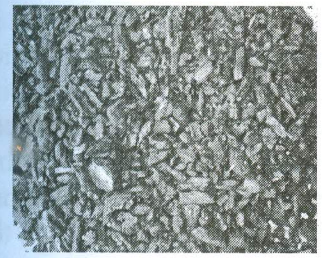
Selecting albasia crotch containing secretion of flea



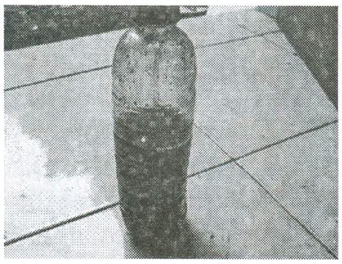
Colony of flea on albasia crotch



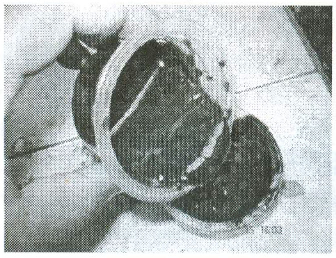
Secretion of flea adhering with albasia crotch



Secretion of flea separated from albasia crotch



Liquid of flea secretion after reacted with methylated spirit



Gel of secretion of flea secretion after heating 180°C, 15 minutes

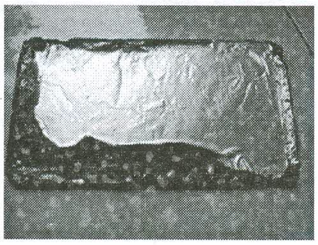
Figure II: Processing of flea secretion

b. Liquefaction of flea secretion for the natural matrix

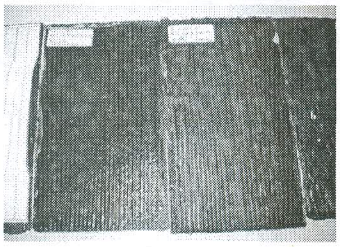
Lumps of flea secretion were liquefied by soaking with methylated spirit in 6 hours at room temperature, the ratio being 1 g of flea secretion against 1 g of methylated spirit. Dilution of the flea secretion will be gel of about 6 days at room temperature. The method used for making the gel from the dilution of flea secretion was heating above 180°C within 15 minutes and then cooling it at room temperature.

c. Making of the biocomposite

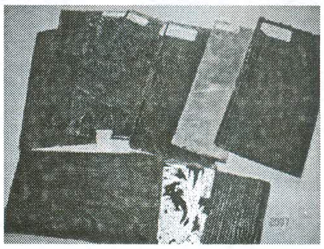
The making of the biocomposite from the secretion of the albasia flea was conducted by pressure molding at elevated temperature about 180°C. The dilution of the flea secretion was layered on a surface of ramie fiber with hand layout method, heated at 180°C in 15 minutes, and then pressured with a load of 20 MPa and held at room temperature. After 8 hours, the biocomposite mould can be unloaded to obtain the biocomposite from the untreated ramie fiber and secretion of albasia flea (Fig. III). Specimens for tensile strength biocomposite test were done by ASTM standard D 638-90 type IV. For the neat matrix test, the method for making the specimen was almost like biocomposite making but without fiber. The size of the specimen and procedure matrix tensile strength testing were done by ASTM D 638-90 type II.



Resolidification of flea secretion as natural matrix



Biocomposite of ramie fiber woven roving and flea secretion



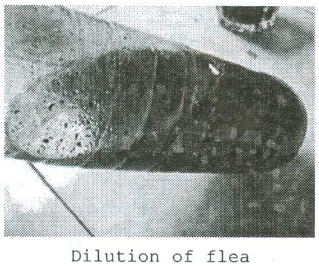
Biocomposite of ramie fiber and flea secretion

Figure III: Flea secretion biocomposite reinforced by ramie fiber.

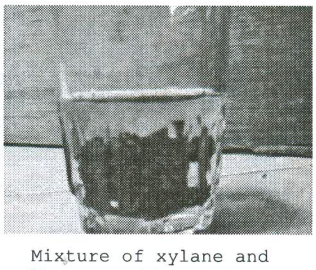
3. Results and Discussion

a. Liquefaction of flea secretion for the natural matrix

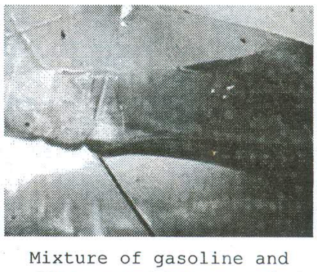
Flea secretion melts entirely after about 6 hours. The dilution will turn into the gel form when placed at atmosphere for about 48 hours, but it will not turn into solid form although kept up to 8 months. The dilution of flea secretion will not change to gel form when placed in closed media up to 8 months and quickly turn into gel form if it is heated above 150°C for about 15 minutes and then cooled at room temperature. This phenomenon is caused by the quick methylated spirit evaporation process so that what remains is flea secretion. Methylated spirit has the analog function with other chemical catalysts. Methylated spirit or alcohol can hydrolysis flea secretion till the phase of the changing from solid to liquid occurs. Other properties of methylated spirit or alcohol are their capability to react with free air so that they tend to evaporate. If dilution of flea secretion is isolated from free air in sealed bottles, the alcohol will not evaporate; so it will remain in liquid form although kept for up to 8 months. Increasing temperature will make alcohol evaporation quicker and affect phase changing from liquid to gel more rapidly compared with room temperature. Certain other chemicals such as xylane, benzene, gasoline and kerosene cannot dissolve the flea secretion (Fig. IV).



Dilution of flea secretion cannot change to gel after 8 months



Mixture of xylane and flea secretion can not li°uefy and dissolve

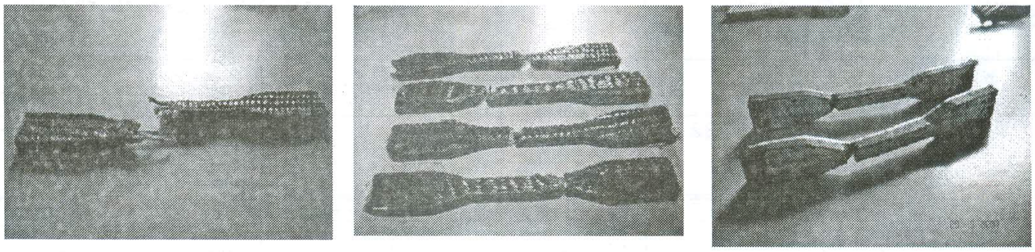


Mixture of gasoline and flea secretion can not li°uefy

Figure IV: Liquefaction process of flea secretion.

b. Tensile strength test of biocomposite

The research results show that the biocomposite materials from ramie fiber and flea secretion have high tensile strengths relative to publicized biocomposite (see Table 2). The biocomposite have 60% volume fraction of ramie fiber of woven roving and matrix of flea secretion, and yield the tensile strength of 80 MPa (see Fig. V). This result indicated feasibility of albasia flea secretion to investigate and develop furthermore because the biocomposite have high tensile strength when compared with other biocomposite made from 30 % volume fraction of ramie fiber uniform direction and epoxy or 30 % ramie fiber uniform direction and polyester (Marsyahyo, 2005). Some research articles also supported this result which reported tensile strength of biocomposite between 12-330 MPa (see Table 1).



Fibrous fracture of tensile strength specimen test (48 MPa) — Non fibrous fracture of tensile strength specimen test (80 MPa) — Tensile strength specimen test which coated aluminium

Figure V: Biocomposite material from ramie fiber and flea secretion, and tensile strength specimen.

The appearance of the tensile strength specimens was partly non fibrous fracture but it looked like brittle fracture on cross section of metal. This finding shows that the tension distribution is spread evenly on cross section of specimen and affected by fiber homogeneity to detain the burden. The cross section of the fibrous fracture specimen indicates that the fiber damage did not happen concurrently, but fibers detained the burden by turns, so lowering the tensile strength (48 MPa). The fibrous fracture form was caused by the non linear fiber formation where the cutting size of ramie fiber woven roving was bigger than the size of the mould causing the folding of the fiber surface. This case can be avoided by making smaller cutting sizes of fiber compared to the size of the mould so the folding of fiber surface when loaded will not happen. When using Rule of Mixture analysis, the tensile strength of the biocomposite was lower affected by the molding temperature of 180°C. This result agrees with Marsyahyo's research result (2005) that ramie fiber can be embrittled at temperature 140°C decreasing the tensile strength fiber.

Table 1. **Tensile Strength of some Natural and Synthetic Fiber Reinforced Composites**

Composites	Tensile strength (MPa)	Density (gr/cm^3)	Explanation	References
Thermoplastis				
Sekresi kutu+60 % rami	80	1,17	Woven roving and untreated	Mujiyono et al (2007)
Polyester + 30,40,50 % rami	47,48,58	-	fibers UD	Marsyahyo et al (2005)
PP + 30 % Flax	52	1,07	Non-woven	Sanadi dkk (1995)
PP + 20 % Flax	30-35	1,03	Lf = 3-25 mm	Garkhail dkk (2000)
PP + 30, 40, 50, 60 % Flax	40, 45, 50, 60	1.02-1,24	Dew ratted	Mieck dkk (1996)

PP + 40, 50 % kenaf	56,33 (65)	1,07	Untreated, (MAPP)	Caulfield dkk (1999), (1998), Karmaker dkk (1996), Sanadi dkk (1995)
PP + 50 wt % Jute	72	1,08	Non woven	Sanadi dkk (1995)
PE + 50 % Kenaf	12 (27)	1,16	Untreated, (MAPP)	Caulfield dkk (1998)
PP + 57-68 wt % Hemp	47-51	1,23	Non woven, needle punced mat, Lf=75 mm	Pervaiz dan Sain (2003)
PP + 25-50 wt % Flax	21-56	1,00 - 1,13	Non woven	Oksman (2000)
PP + 50 % Sisal	37, (65), (67)	1,17	Untreated, (2% MAPP), (4% MAPP)	Caulfield dkk (1999)
PP + 30 wt % Sisal	5 - 27	1,07	Non woven	Jayaraman (2004)
LDPE + 10, 20, 30 wt % Sisal	15 (18), 22 (24), 31 (34)	0,96 - 1,05	Untreated, (alkali treated)	Joseph dkk (1996)
MaterBi + 20, 40, 60 % Flax	48, 73, 78	1,34 - 1,42	Thermoplastic biopolimer (starch based) with UD fibre	Romhány (2003)
PP + 20 % Flax	32 (20)	1.02	No rubber, (matriks 70 % PP, 30 % rubbery additive). Injection moulding	Biagiotti (2003)
PP + 40 % Kenaf	27 (41) [48]	1,07	Untreated, (2 % MAPP), (5 % MAPP). Lf = 1,58 mm. Injection moulding	Karnani (1997)
PP + 40 wt % Flax	50 - 70	1.07	NMT	Karger-Kocsis (2000)
PP + 50 wt % Glass	80 - 100	1.56	GMT	Karger-Kocsis (2000)
PP + 50 wt % Jute	30 (60)	1.17	Untreated , (6 % MAPP). Injection moulding. Lf=0,39 mm	Karmaker dkk (1996)
PP + 30, 40, 60 wt % Jute	47, 57, 73	1.07-1,21	3 % MAPP. Lf = 10 mm	Rana dkk (1998)
PP 40 wt % Glass	110	1,24	Non woven	Caulfield dkk(1998)
PP 40 wt % Glass	77	1,24	GMT	Oksman dkk (2000)
Thermoset				
Epoxy + 30,40,50 % rami	60,79,86	-	UD fibers	Marsyahyo et al (2005)
UP + 30 % Flax	44	1.16	Non woven	Oksman dkk (1998)
Epoxy + 30 % Flax	54	1,2	Non wovwn	George (1999)
Epoxy + 25,43,50,60,74 % Sisal	160, 200, 250, 0300, 330	1,19 - 1,26	U fibers	Ronga dkk (2001)
Melamine Formaldehyde + 22 wt % Flax	37-43	1,49	Non woven	Hagstrand (2001)

UP + 15 % Flax	26-43 (28-43)	1.10	Untreated, Glycol treated	O'Dell, J.L. (1997)
UP + 15 % Glass	91 - 114	1.26	Random	O'Dell, J.L. (1997)
UP + 22 wt % Flax 38 % Chalk filler	35 - 75	1,4	Lf = 6, 13, 25, 38 mm	Plotkin (1997)
UP + 22 wt % Glass	35 - 75	1,4	Chopped	Plotkin (1997)
UP + 50 % Sisal	30 (40) [34]	1,26	Untreated, (Methacrylamide treated) [Silane treated]. Nono wovwen mats	Singh dkk (1996)
UP + 17, 33 wt % Coir	12, 24	0,96 - 1,08	Lf = 150 mm. Non wovwn mats	Rout dkk (2001)
UP + 60 wt % Glass	27-44	1,26	RTM	Rowell (1999)
UP + 60 wt % Jute	85 -117	1,92	RTM	Rowell (1999)
UP + 45 wt % coir	27-44	1,26	RTM	Hill and Khalil (2000)
UP + 45 % Glass	94	1,7	Non wovwn mats	Hill and Khalil (2000)
UP + 30 wt % Pineapple	52 (73)	1,09	untreated (silane treated). Lf = 30 mm	Devi (1977)
UP + 30 wt % Palm leaf	15,6 (35) [53]	-	Lf = 5 mm (Lf = 10 mm) [Lf =30 mm]	Lee dkk (2001)
Epoxy + 28,46 % Sisal	169, 211	1,16	UD fiber	Oksman dkk (2002)
Epoxy + 32 % Flax	132	1,23	UD fiber, RTM	Oksman dkk (2002)
Epoxy + 48 % Glass	817	1,71	UD fiber	Oksman dkk (2002)

4. Conclusion

The biocomposite which is made from the natural matrix of albasia flea secretion and ramie fiber has a relatively higher tensile strength than many publicized biocomposites. Processing of flea secretion flea is very simple and not dangerous from the taking process to the application of the natural matrix. Another advantage of the biocomposite is that all the natural resources can be renewable and environmentally friendly. Therefore, biocomposite of albasia flea secretion and ramie fiber can become a reasonable new material for the construction field. Further development and research of the biocomposite is still needed in order to increase the economic and beneficial values of the biocomposite looking at, for example, the optimal fiber treatment, chemical composition of flea secretion, compatible fiber type, and appropriate technology for making of biocomposite commercials.

Implication of the study is for the faculty of engineering to develop of new teaching material in the engineering material subject especially under the topic of composite material. In the long run, the faculty of engineering of Yogyakarta State University may register the biocomposite as a trade mark of the university.

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