

Wood and Bamboo Fiber Combination in the Production of Poly Lactic Acid (PLA) composite

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Abstract: Bio-composite made from a combination of natural fibers such as wood fiber (wood hard or soft) or other fibers (fiber grain, flax, sisal and hemp) in a polymer matrix. In this study, natural fibers such as cellulose synthesized from Meranti wood (KM) and Betung bamboo (BB) as a matrix or reinforcement material poly lactic acid (PLA) are biodegradable. Tensile and flexible strength tests carried out using Universal Testing Machine (UTM). Flexible and tensile tests that bio composite Betung bamboo better than Meranti wood. Apparently the flexion strength of the composite KM between 10% and 20% there was no significant difference, In contrast to the composition of the bio composite between 10% and 20%. Flexion strength has height values contained in the bio composite Betung Bamboo 20% of 57.4054 N/mm². The highest power of elasticity found in the composition of the bio composite Betung bamboo 20% of 1.95 GPA. Betung bamboo is high strength reinforced silica matrix composite.

Keywords: Bio composites, poly lactic acid, Meranti wood, Betung bamboo

I. Background

Natural lignin cellulose fibers can be made from wood and non-wood (bamboo, sisal, hemp, etc) is a very abundant material on earth. As the amplifier component in composite materials, natural fibers have advantages over synthetic fibers, among others, it is renewable, recyclable and biodegradable in the environment [1]. Among natural fibers have the good mechanical properties and is cheaper than synthetic fibers. Natural fibers have several drawbacks, especially its weakness absorbs of water, quality is not uniform, and has low stability to heat. Cellulose is an organic compound with the formula $(C_6H_{10}O_5)_n$, polysaccharides consisting of a linear chain of several hundred to over ten thousand bond β (1 \rightarrow 4) D-glucose units. Cellulose can be produced by chemical treatment. On the study of the chemical treatment is given to extracting solution, the removal of lignin (with sodium chlorate) and removal of hemicellulose with potassium hydroxide solution [2]. The result is pure cellulose with α -cellulose content of more than 85%. Poly lactic acid is polyester that can be produced using raw materials of renewable natural resources such as starch and cellulose through lactic acid fermentation. Chemically for produced PLA polymerization of lactic acid can be done in two ways, namely directly of lactic acid and indirectly through lactide former (lactic acid dimmer) in advance and followed by polymerization into PLA. Bio composite is a combination of natural fibers (bio fibers) such as wood fiber (wood hard or soft) or fiber other than wood (grain fiber, hemp, jute, sisal and flax) with a matrix which is usually made of polymers [3]. Based on such understanding, bio fibers is an important component of the bio composite material. This fibrous material is derived from the fiber of trees, plants or shrubs so called bio fibers [4, 5]. Composite nature or bio fibers currently serves as an alternative material of glass fiber composite. Bio fibers are growing rapidly as an additive in thermoplastic material. Development of the bio composite material is constantly evolving, especially research on the interface (interface) bio composites, bio composite design, fabrication process bio composites and process characterization [6, 7].

II. Material and Methods

2.1 Instrument and Material

Instruments were conducted using oven, stirrer, labo plastomill, UTM, FTIR. The chemical used were PLA LACEA H-280, Meranti wood (KM), Betung bamboo (BB), Sodium Chlorate 25%, acetic acid, 5% KOH, ethanol, acetone and distilled water. All Chemical was analytical grade and obtained from Sigma, Esun and Merck.

2.2 Methods

Preparation of raw materials sample of wood and bamboo made small pieces and then crushed with a hammer mill and then filtered to obtain wood and bamboo powder with 40-60 mesh size. Preparation of powdered cellulose Fiber is 1.5 g powder Meranti wood or Betung bamboo with distilled water, sodium chloride and acetic acid, heated in the water bath for one hour at a temperature 80°C. The process is repeated up to four

times the replication. Wash with distilled water until a neutral pH cleaner and then strain. After washing and screening process was added 15 ml of 5% KOH and 30 ml of Cellulose fibers and PLA (refer to Table 1) mixed with ethanol for one hour followed by filtration or centrifuge to remove the liquid phase (water and ethanol).

The process is repeated 2 times to replace the water with ethanol, replaced with acetone. Cellulose which has been evaporated dispersed into the solvent acetone. Furthermore, the PLA was added slowly to the dispersion of the cellulose, stirring constantly. After the PLA in acetone, stirring is continued for 2 hours for PLA and cellulose mixed evenly. PLA and the cellulose mixture was then poured into a Teflon-coated tray and dry them for a day at room temperature, followed by vacuum drying at a temperature of 50 °C for 8 hours and then the mixture was dried and cut into small pieces done bleeding process using various labo plastomill at a temperature of 140 °C and cooling in the cold press for 3 min 0.1 MPa. The importance of the film sheets can be used for further testing [1, 2]. Bending and tensile tests were measured by Universal Testing Machine (UTM). Results shown are the average values of the five samples. Analyze group function of poly lactic acid bio composites and cellulose fibers from wood and Betung bamboo were characterize analyze by FTIR (Fourier transformation Infrared [8].

Table I. The composition of the composite

Samples	Cellulose(g)	PLA (g)
PLA	0	60
10 w/v %	6	54
20 w/v %	12	48

III. Discussion

3.1 Preparation of Powdered Cellulose Fibers of Meranti Wood and Betung bamboo

Cellulose fibers can be synthesized from wood or bamboo powder by adding a solution of sodium chloride and acetic acid to remove the lignin content. Lightning are not regular, random, and a major constituent of the aromatic compounds, which increase the elasticity matrix of cellulose and hemicellulose. As a result of this complexity lignin cellulose is a component that is hard to be broken. This is because the crystal structure of lignin is higher than the cellulose and hemicellulose. Lightning is an undesirable component in the process, beside disrupting the performance of the enzyme; lining also because behind the cellulose bonds result in an increased number of needs enzymes used for hydrolysis. Aim the addition of KOH for eliminating hemicellulose.



Fig 1. Cellulose Fibers from Meranti Wood and Betung Bamboo

PLA is flexibility enhanced by mixing with cellulose fibers. The mixing process of the PLA and cellulose fibers using an ethanol solution to remove water content contained in the cellulose fibers which subsequent addition of acetone has been used to dissolve the PLA since PLA soluble in organic solvents.



(a)



(b)

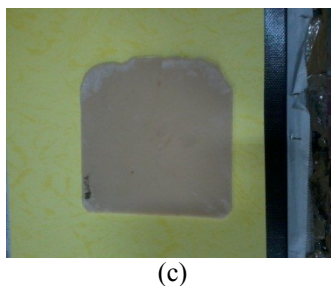


Fig 2. Mixture of PLA and cellulose fiber (a), labo plastomill (b), the composite is formed (c)

3.2 Silica modified

Silica sand is used for the modification of poly lactic acid in characterization using a x-ray fluorescence spectrometer (XRF). This method is a method of analysis of a material nature does not destroy the (non-destructive). X-ray source used to radiate the sample and choose the elements in the sample issued the x-ray characteristics they have. When an element is shot by the x-rays, the radiation characteristic will be issued as a form of energy that will be used in the transfer of electrons from one orbital to another orbital. The primary beam of tube (tube) x-rays cause luminescence characterized by straight lines of the elements contained in a sample. A level of Silica in the silica sand was 223949 ppm.

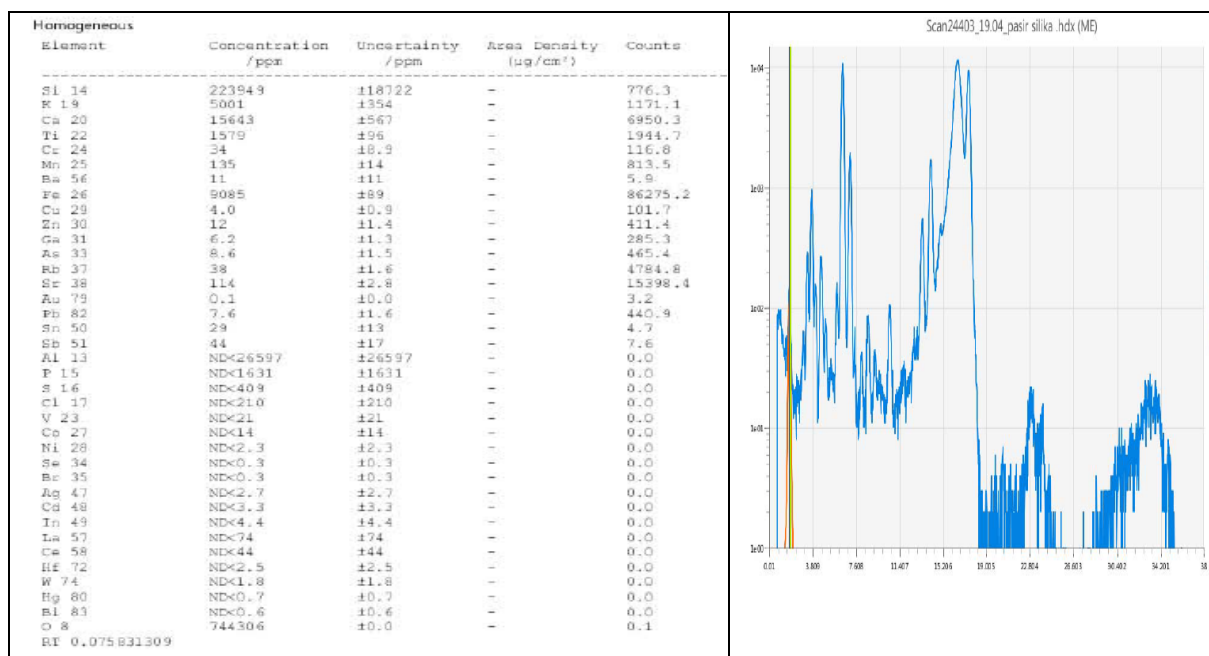


Fig 3. using x-ray Fluorescence spectrometer of silica sand

3.3 Characterization of Cellulose Fibers

Cellulose is obtained as cotton and white. To determine whether the cellulose fibers which have been obtained properly containing cellulose fibers then determine group functions using FTIR. Spectrum FTIR results shown in Figure 2 (a) and (b), each having peaks at certain wave numbers. The wave numbers can be seen in Table 2. At Meranti wood and Betung bamboo have nearly the same wave numbers and produce nearly the same peak. On absorption wave numbers 3400 cm⁻¹, 2900 cm⁻¹, 1635 cm⁻¹, 1429 cm⁻¹ are OH, CH, C = O and CH₃ aliphatic compound. The functional group from cellulose chain at Meranti wood and Betung bamboo are hydroxyl. Group-OH can interact with each other with the-O, -N, and-S, forming hydrogen bonds. -H bonds also occur between the-OH groups of cellulose with water. Cellulose-OH groups cause a hydrophilic cellulose surface. Cellulose chain has a-H group at both ends. End-C1 has reducing properties. The cellulose chain structure is stabilized by strong hydrogen bonds along the chain. In the nature of plant cellulose, cellulose chains are tied together to form micro fibrils highly crystallized (highly crystalline) cellulose chains in which each tied together by hydrogen bonds.

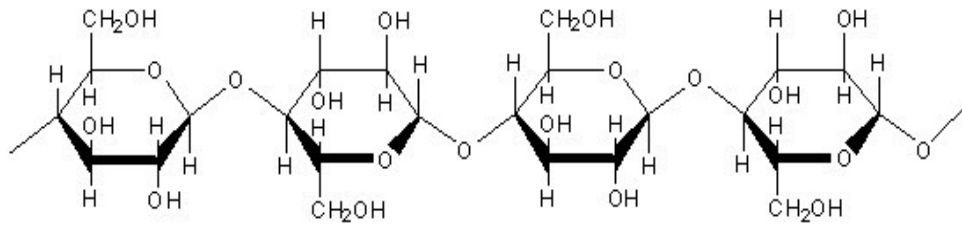


Fig 4. Molecular structure of cellulose

Table 2. The wave numbers at Meranti wood and Betung bamboo

Vibration	Wavenumber (cm ⁻¹)	
	Meranti wood	Betung bamboo
O-H	3402.22	3433.36
C-H aliphatic	2901.06	2917.56
C=O	1634.66	1635.80
CH ₃	1429.61	1432.56

Fiber alignment greatly affects the tensile and flexion strength, the smaller the fiber direction α to the load imposed on the composite, the greater its power and increase as the volume fraction of filler in the composite fibers with polyester resin can improve the tensile strength and Bending test carried out using Universal Testing Machine (UTM). On the flexible strength testing in lab created special conditions of the test sample is designed as Figure 5. Sample design for flexible test results will be obtained from the data loading. The data from the test obtain equation the bending stress. The maximum bending stress is symbolized by the MOR (Modulus of Rupture). From Figure 5 apparently the flexible strength of the composite KM between 10% and 20% there was no significant difference, In contrast to the composition of the bio composite between 10% and 20%. Flexion strength has the height values contained in the bio composite Betung Bamboo 20% of 57.4054 N/mm². Tensile Test, many engineering tension test is performed to complete the design of the basic information and the strength of a material as supporting data for material specifications. In the tensile test, the specimen is subjected to load a coaxial tensile force increase continuously, along with the observation of the extension of the specimen experienced. Engineering stress strain curve obtained from the measurement of the extension of the test specimen. Bio composite tensile and flexible strength test is done using UTM. The data from tensil test are shown in figure 6.

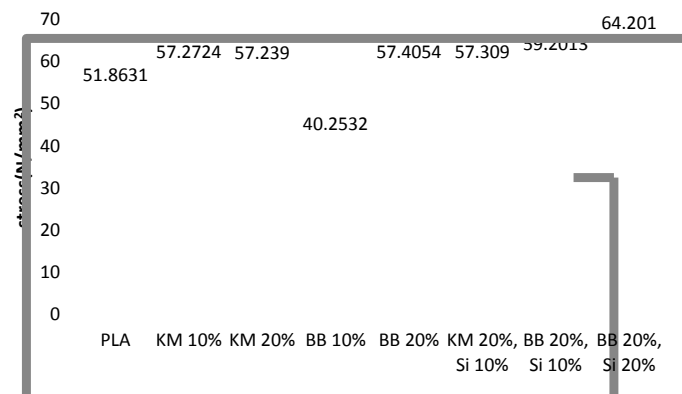


Fig 5. Flexible strength

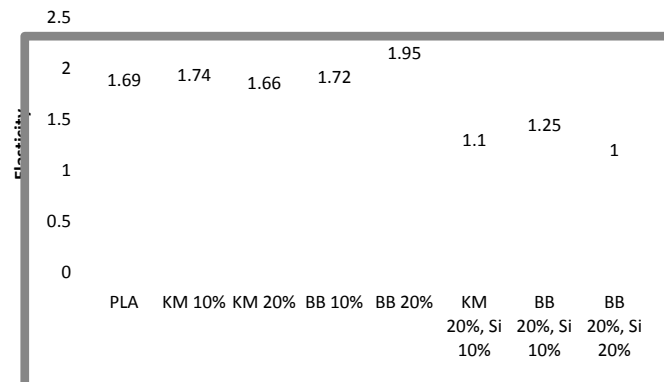
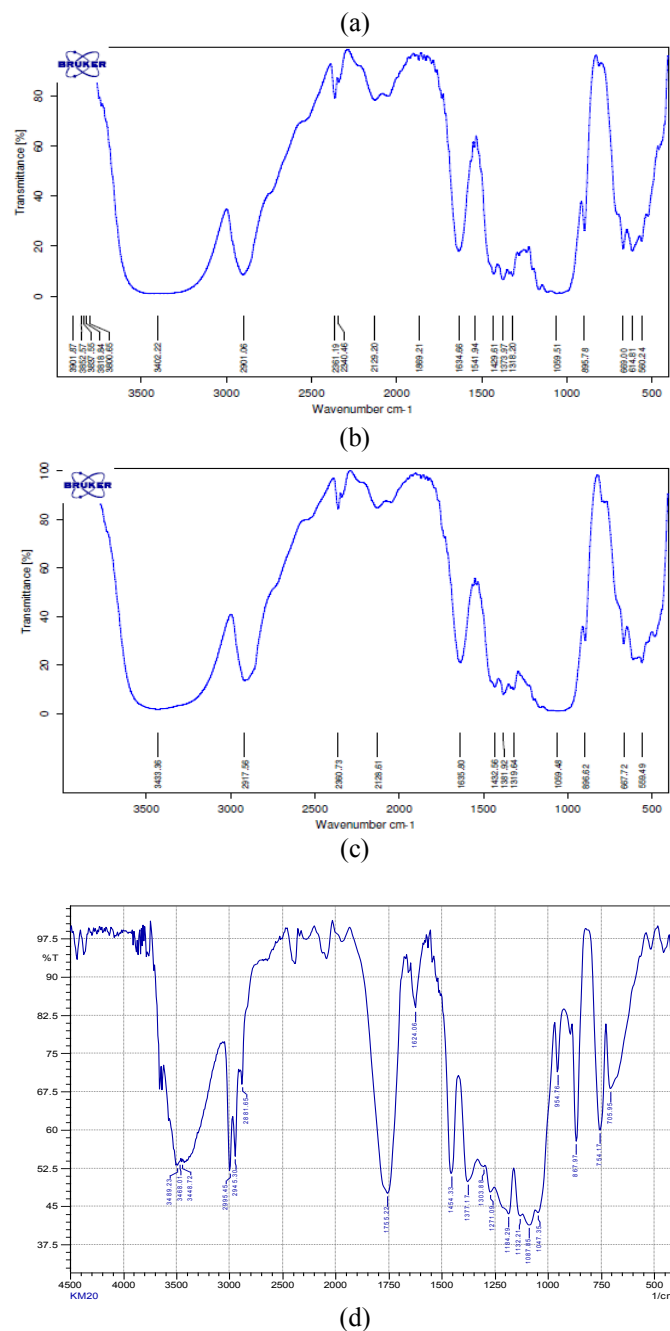


Fig6 .Result Data of Tensile Test from PLA, PLA composite Meranti wood, and Betung bamboo

Tensile Yield Break elongation modulus apparently the highest power of elasticity found in the composition of the bio composite Betung bamboo 20% of 1.95 GPA. Addition of silica sand is high strength reinforced silica matrix composite.

FTIR analysis is used to determine the functional groups that are formed from the resulting samples. FTIR spectra were measured with a FTIR Perkin Elmer. The test sample is crushed to powder form and was evaluated by engineering KBr₂ pellets, then measured the transmission or absorbent.

In this study, FTIR analysis for determination functional groups of cellulose fibers on Meranti wood and Betung bamboo, FTIR spectrum is the result shown in Figure 7. Spectrum is shown in In the absorption spectrum of the PLA are the C-H stretching appear in wavenumber 2900 cm⁻¹, group C = O (carbonyl) at 3200 wave numbers where overtone and carbonyl groups experienced wave length 1700 on the carbonyl group and the experience stretching wave numbers 1300 and 1500 are C-O-C group and CH₃. For cellulose KM and BB have nearly the same wave numbers and produces a peak in the spectrum is almost the same due to the bio composite compounds are the same, namely cellulose and PLA. However, the only difference being the absorbance values for the color of bamboo bio composite Betung bamboo is turbid than the Meranti wood.



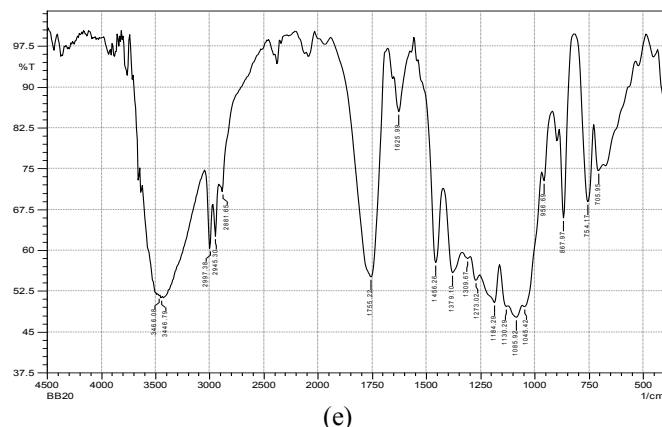


Fig 7. Spectrum of PLA (a), Meranti wood cellulose fiber (b), Betung bamboo cellulose fiber (c), bio composite KM (d), bio composite BB (e) .

Cellulose is obtained as cotton and white. To decide whether the cellulose fibers which have been obtained properly containing cellulose fibers then determine group functions using FTIR. Spectrum FTIR results shown in Figure 2 (a) and (b), each having peaks at certain wave numbers. The wave numbers can be seen in Table 3. At Meranti wood and Betung bamboo have nearly the same wave numbers and produce nearly the same peak. On absorption wave numbers 3400 cm^{-1} , 2900 cm^{-1} , 1635 cm^{-1} , 1429 cm^{-1} there are OH, CH, C = O and CH_3 aliphatic compound. The functional group from cellulose chain at Meranti wood and Betung bamboo are hydroxyl. Group-OH can interact with each other with the-O, -N, and-S, forming hydrogen bonds. -H bonds also occur between the-OH groups of cellulose with water. Cellulose-OH groups cause a hydrophilic cellulose surface. Cellulose chain has a-H group at both ends, -C1 has reducing properties. The cellulose chain structure is stabilized by strong hydrogen bonds along the chain. In the nature of plant cellulose, cellulose chains are tied together to form micro fibrils highly crystallized (highly crystalline) cellulose chains in which each tied together by hydrogen bonds.

Table 3. Functional Group Meranti wood and Betung bamboo in PLA Composite

Vibration	Wavelength (cm^{-1})						
	PLA	cellulose KM	cellulose BB	Bio composite KM 10%	Bio composite KM 20%	Bio composite BB 10%	Bio composite BB 20%
OH	-	3402	3433	3485	3489	3487	3466
C-H stretching	2900	2901	2917	2995	2995	2997	2997
C=O dan	3200	1634	1635	1755	1755	1755	1755
C-O-C Stretching	1300	1373	1381	1379	1377	1377	1379
CH_3 bending	1500	1429	1432	1454	1454	1456	1458

The IR spectrum for 10% and 20% of silica modified shows the carbonyl stretching vibration at 513.07 cm^{-1} and $511,14\text{ cm}^{-1}$ this indicates that Si-OH groups. 956.69 cm^{-1} and 920.05 cm^{-1} indicate si-O-Si and 3853.18 cm^{-1} indicate the existence of the cluster - OH.

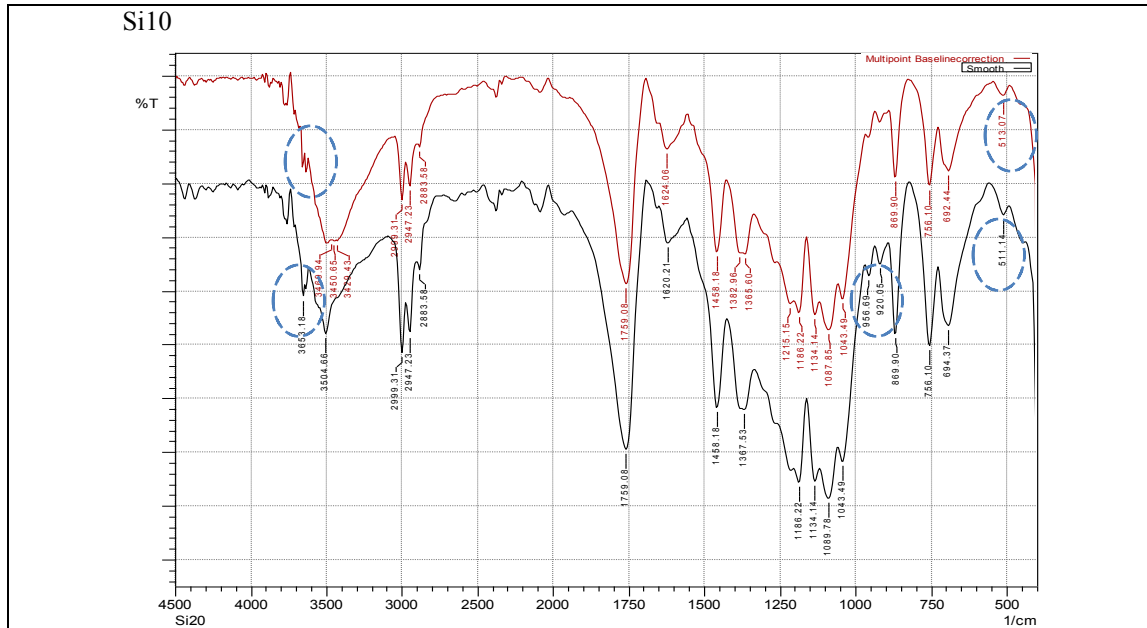
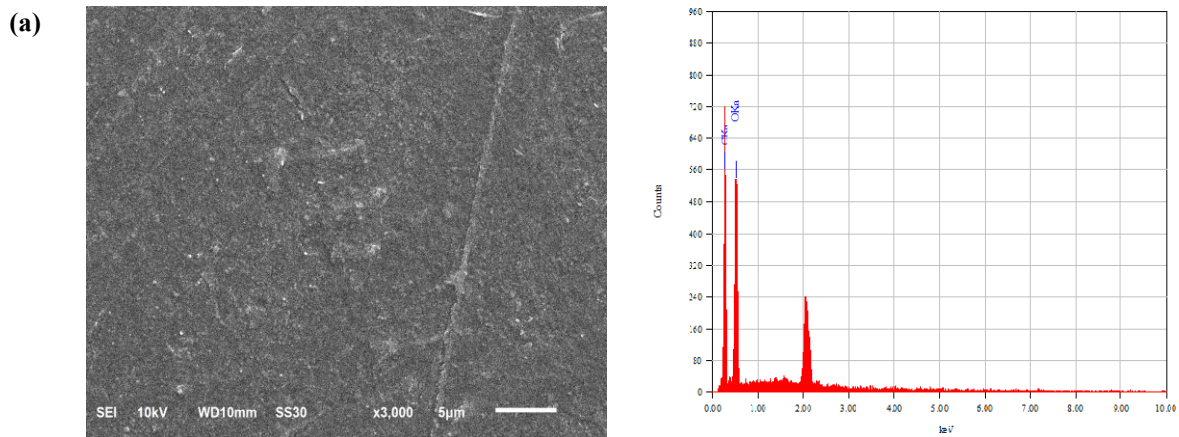


Fig 8. Spectrum of PLA-selulosa bamboo with silica modified

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3.4 SEM/EDX Image

Energy-dispersive x-ray spectroscopy is used for the elemental analysis or chemical characterization of a sample. It relies on the investigation of an interaction of some source of x-ray excitation and a sample. Its characterization capabilities are due in large part to the fundamental principle that each element has a unique atomic structure allowing an unique set of peaks in its x-ray spectrum. Based on the results of the EDX on PLA Betung bamboo consists of carbon 43, 27% and oxygen 56.28%. Results of EDX PLA with Betung bamboo and silica sand as a modifier composing the element carbon.



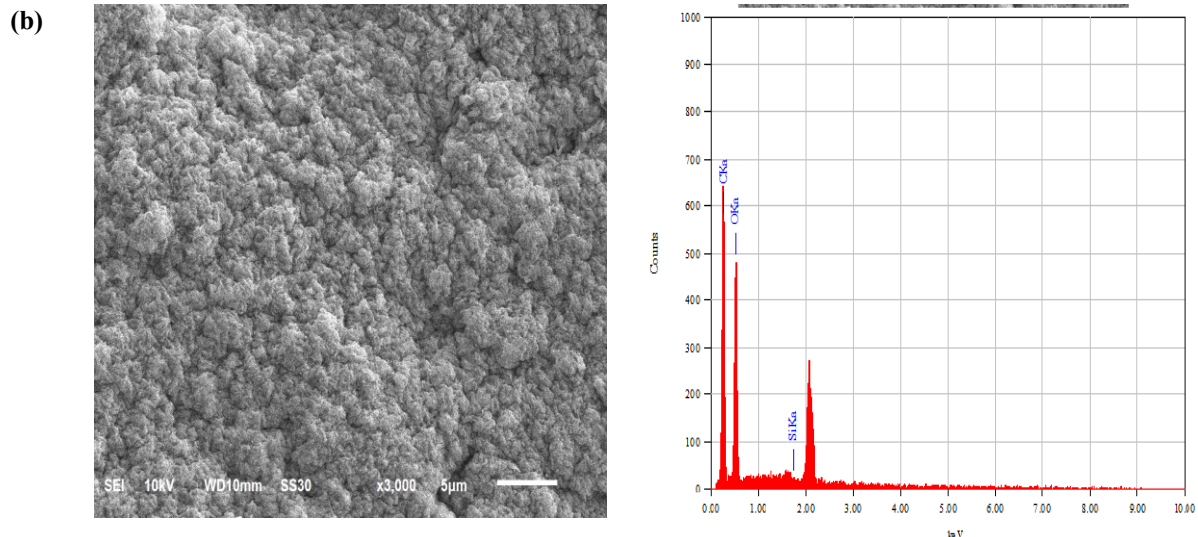


Fig 8. SEM/EDX image for composite PLA, unmodified silica sand (a), modified silica sand(b)

IV. Conclusion

Composites can be made by mixing cellulose fibers from Meranti wood or Betung bamboo with PLA matrix so that there are better mechanical properties. Bending stress and tensile strength is highest at 20% between bamboo for composite PLA of 57.4054 N/mm² and 1.95 GPA. Betung bamboo is high strength reinforced silica matrix composite.

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