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Effect Of Turmeric (Curcuma) Solution Treatment Toward The Interfacial Shear Stress And Wettabilty Of A Single Fiber Akaa (Corypha) On Epoxy Matrix

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Absract

The purpose of this study is to determine the effect of turmeric solution (Curcuma) on the fiber sheath Akaa (Corypha) toward the interfacial shear stress (IFSS) and wettability on epoxy resin matrix. The first treatment of Akaa fiber sheath is soaked in distilled water. The second treatment is fiber boiled in a turmeric solution for 1 hour. The third treatment isboiled in the turmeric solution for 2 hours and the fourth treatment is boiling the fiber in a turmeric solution for 3 hours. The boiling temperature is 100° C and under a pressure of 1 atmosphere. Each fiber sheath Akaa after treatment, was dried at room temperature for about 48 hours. The solution used is 20% of turmeric powder and 80% distilled water under a unit volume.The matrix material is a thermoset epoxy. A tensile testing was done to obtain the specimen shear stress based on the ASTM 3309-02 rule and wettability rule. Furthermore a SEM and Energy Dispersive X-Ray Spectroscope (EDS) test was done to get the fiber composition and fiber chemical composition. The hydrolysis test and Fourier Transform Infrared Spectroscopy test (FTIR) was done to determine the hemicellulose composition, cellulose composition, lignin composition.From the results showed that the turmeric treatment would affect the single fiber interfacial shear stress and single fiber wettability. The highest shear stress is 29.48 N/mm^2 in fibers treated for 1 hour boiled in turmeric solution.

Keyword: Akaa single fiber, turmeric (curcuma)treatment, shear stress, wettability.

INTRODUCTION

In general, composite materials can be described as a combination of two or more materials on a macroscopic scale to form a useful material [1]. Composite generally have a reinforcing material such as fiber and matrix as a binder. To produce cellulose fiber based with a qualified mechanical properties it is necessary to treat the fiber surface because it has a hydrophilic properties which has an opposite nature with matrix polymer which is hydrophobic. Fiber surface treatment or sizing is expected to improve the fiber wettability and the fiber adhesion bonding to the fiber [2, 3].Lots of effort has been done either physically or chemically to carry out the fiber surface improvement and the interaction between the fiber and the matrix. The first way which is always used is the initial treatment of fibers by chemical treatment [4]. The fiber chemical treatment could change the surface fiber topography, which would clean the fiber and improve the fiber surface roughness as a result of moisture absorption termination process. The fiber surface topography changing would influence the fiber mechanical property, especially the interfacial shear stress and the fiber matrix bonding strength. Methods to see the changes and determine the interfacial shear stress between fibers and matrix could be done through a micro-bond / pull-out, through a single fiber and multi fiber fragmentation test and micro tension [5]. However the single fiber pull out test is the best to be implemented and is the best experimental technology to determine the natural fiber composite mechanical properties [6]. To eliminate the low mechanical properties such as wax, pectin and lignin is one way to improve the interfacial shear strength and the strength of the fiber-matrix adhesion [7]. In general, chemical treatment would raise the elasticity modulus greater than the natural fibers without treatment. Fiber pre-treatment is still needed to improve the natural fibers strength as a composite reinforcement [8, 9]. Chemical treatment using alkali (NaOH) and silanecoupling agent on the natural fiber cellulose treatment as a strengthen media on the composite-matrices is widely used [7]. Another chemical media used is the potassium permanganate ($KMnO_4$) [10], and hydrogen peroxide (H_2O_2) [11,12]. The advantage of a composite is that the overall characteristic has a better characteristic then the individual elements. The properties that can be improve on a composite material is the material strength, stiffness, corrosion resistance, surface finish, weight and fatigue life [13]A composite material is a bond between fiber and matrix where the characteristic is involving fiber wettability. The wettability parameter is determined by the contact angle formed by the matrix and fiber surface and also by the interfacial bonding[14].The smaller the wettability contact angle the better it is, so that the matrix as a fiber adhesive could have an ability to cover the whole fiber surface optimally. The contact angle to reach an optimal wettability is not more than 30°.Quantitatively, *wettability*could be identified from the contact angle (θ)between the dense fiber and the matrixliquid in a form of droplet[15].

Various methods and engineering technology of fiber is passing a pretreatment process (characterization) by chemical treatment, but with the use of natural ingredients such as turmeric has never been done by previous researchers.

Turmeric (Curcuma) has many substances that allow to be used for human life. A Research was conducted to get an optimal soaking time and the best turmeric concentration given to the specific food life time. The result is that the specific food life time arise after been soaked in a turmeric solution compared with the untreated food. As a result turmeric is used for many food preservatives; turmeric has a same capability with formalin as preservative. Theoretically turmeric is a plant that has pretty much anti-oxidant in it[17].

The purpose of this study was to determine the effect of natural ingredients treatment such as turmeric towardthe fiber IFSS and wettability. The highest shear stress determined should be the best result. Afterwards by looking at the changes in the fiber morphology and fiber topography of the Akaa stem fiber to determine the best fiber conditions. Furthermore determine the fiber absorption ability and the fiber composition content to determine the best treatment of a single fiber Akaa stem.

MATERIAL AND METHODS

The material used is an Akaa (Corypha) midrib fiber, turmeric liquid (Curcuma), epoxy resin matrix and distilled water. Akaamidrib was obtained from Akaatrees that grow in the Wajoarea South Sulawesi province, Indonesia. Akaamidrib fiber was taken manually by means of Akaamidrib pounded using a rubber mallet until loosen and become separated and the fiber appears.After that the fiber is taken or repeal manually. Firstly the Akaa midrib fiber should soaked in a distill water. The subsequent treatment is putting the fiber inside a boiled turmeric solution with boiling variations time of 1 hour, 2 hours and 3 hours. The boiling temperature was controlled to be 100°C at a pressure of 1 atmosphere. Furthermore, after the treatment is done, all the fibers were dried at a room temperature 30°C-32°C for 48 hours. The turmeric solution used is a solution with a concentration of 20% turmeric powder and 80% distilled water by volume base. The epoxy material is a thermoset resin matrix produced by Epos Chon Company.

Table 1: Notation single fiber treatment

Notation	Information
NT	Non Treatment
AT	Soaked with distilled water for one hour
TT1	Turmeric Treatment for one hour
TT2	Turmeric Treatment for two hours
TT3	Turmeric Treatment for three hours

Akaamidrib fiber without treatment is notated as NT. The first treatment is soaking the Akaa midrib fiber in distilled water for 1 hour and is notated as AT. The midrib fiber second treatment is soaking it in a boiled turmeric solution for 1 hour which is noted as TT1. The third treatment is soaking the midrib fiber in a boiled turmeric solution for 2 hours and notated as TT2. The last treatment is soaking the midrib fiber in a boiled turmeric solution for 3 hours and was notated as TT3. Finally the midrib fiber was cooled down for 48 hours in room temperature.

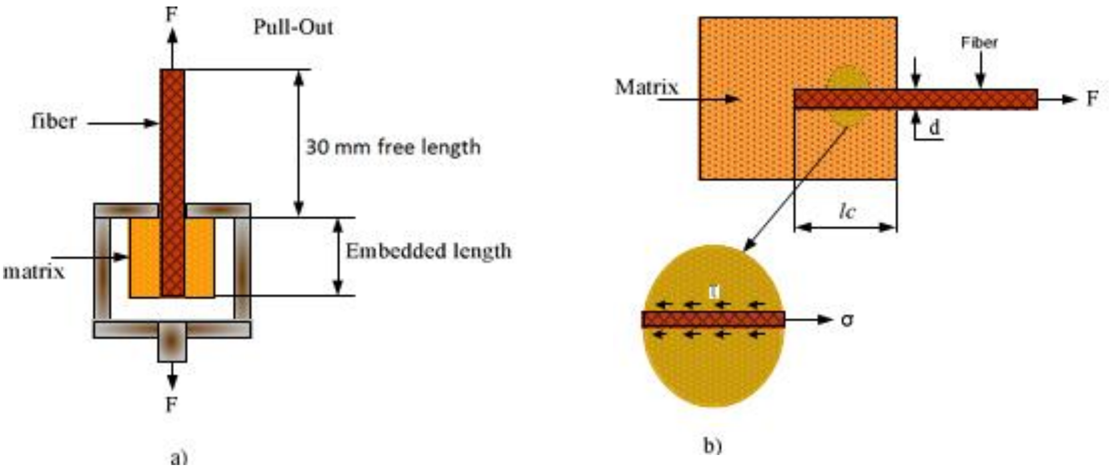


Figure1: Pull Out Test mechanism.a).Single fiber specimenpull out test. b). Equilibrium stress and interfacial shear forces between the fiber surface and the matrix(17).

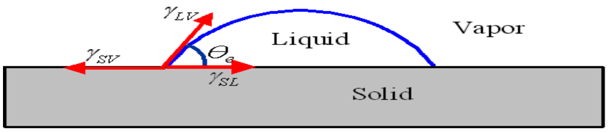


Figure 2: Contact Angle Illustration[18].

Figure 1 is a Pull Out test mechanism. Single fiber midrib Akaa pull-out testing is using a tensile test equipment Testometric M500-25CT DBBMTCL 2500 kg ROCHDALE ENGLAND. The test is conducted to determine the fiber adhesion capability between fiber and matrix.Pull-out test specimens were made by means of fiber planted perpendicular to the matrix with embedded fiber length of 0.5 mm and the other end attached to the paper. The specimen length is 30 mm, based on the ASTM 3379-02 rule on the withdrawal speed of 5 mm/min. The Akaa fiber diameter on average of 0.45 mm, measured with a digital microscope 500 times magnification. The test procedure is simple pull-out is shown in Figure 1. The tests were conducted for the fiber NT, AT, TT1, TT2 and TT3 treatment.

Fourier Transform Infrared Spectroscopy Test (FTIR) using Shimadzu 8400. The tests were conducted in a manner where the specimen in the form of the extract was put in the FTIR machine. The test result is a chart that was displayed on the monitor screen.To assess the results of the test chart an IR characteristics absorptions table was used. The test is conducted for all treatments. The Scanning Electron Microscope (SEM) test is using an Electron Vega3 Tescan at 5kV. The test was conducted to determine the fiber element content, the fiber morphology and fiber topology. The results are shown in a form of graphs and tables for elements composition and compounds. Hydrolysis test is to determine the fiber hemicellulose, fiber cellulose and fiber lignin.

RESULT AND DISCUSSION

Figure 3 shows the highest interfacial shear stress (IFSS) is on the TT1 treatment of 29.48 N/mm^2 and the lowest was 13.63 N/mm^2 on the NT treatment. The IFSS increaseis due to the fiber rough surface, hollow and grooved, so that when the matrix occurs in the mix a perfect interlocking or bonding occurs. While the IFSS declineon TT2 and TT3 treatment it is shown a number of fiber cells damagedas shown in the SEM images in Figure 7, which resulted a decrease of fiber oxide power absorption or atomic absorption. The fiber topography is seen to be damaged and fragmentary and no longer homogeneous morphology. Then in figure 8 it is seen that TT1 has the highest hemicellulose and cellulose, while lignin is the lowest compared to treatment TT2 and TT3. So it could be concluded that the TT1 treatment has the best fiber result.

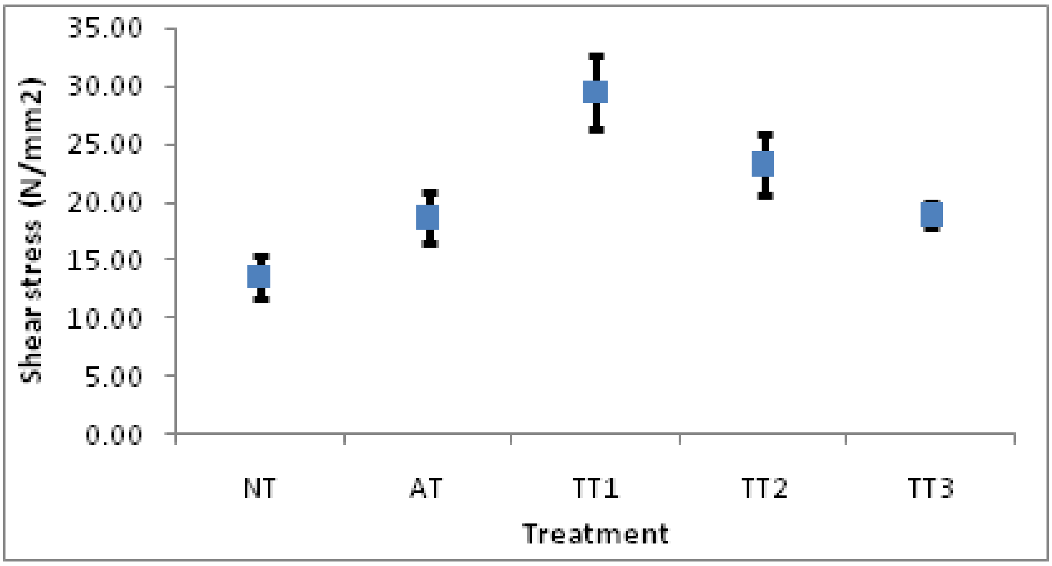
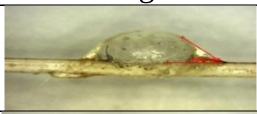
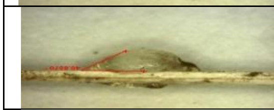


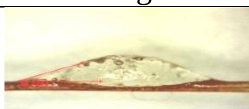
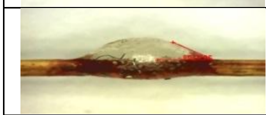
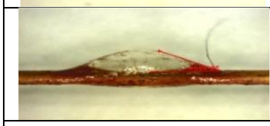
Figure 3: Akaa Single fiber Interfacial Shear Stress

Figure 4 shows the results of wettability testing where NT treatment NT has the highest contact angle value as big as 52,6557°. It shows that the fiber has a lowest bonding ability compared with the AT treatment with an angle of 41.4301°, TT1 treatment with an angle of 29.0192°, TT2 with a contact angle of 21.74772° and TT3 with an angle of contact of17.7166°. Furthermore a fiber low mechanical bonding may cause the bond release between the fiber and the matrix on a composite application called as delamination or de-bonding. The smaller the wettability contact angle, the better the wettability will be. To generate an optimal wettability, the contact angle should not be more than 30° [15]. From the TT2 and the TT3 treatment result it is shown a smaller wettability angle or a better contact angle then TT1. But the SEM test results as shown in Figure 7, shows that the TT1 treatment has the best fiber treatment compared with the TT2 and TT3 fiber treatment.

Wettability Figure Result

No.	Treatment type	Image	angle
1	NT		48,1995°
			55,6698°
			54,0979°
		Average	52,6557°

No	Treatment type	Image	Angle
2	AT		41,5932°
			40,8570°
			41,8402°
		Average	41,4301°

No.	Treatment type	Image	angle
3	TT1		26,7284°
			36,9296°
			23,3996°
		Average	29,0192°

No.	Treatment type	Image	angle
4	TT2		19,9722°
			21,1438°

			24,1272°
		Average	21,7477°

No.	Treatment type	Image	angle
5	TT3		14,8090°
			19,4618°
			18,8791°
		Average	17,7166°

Figure 4: Fiber-matrix contact angle profile of wettability test results

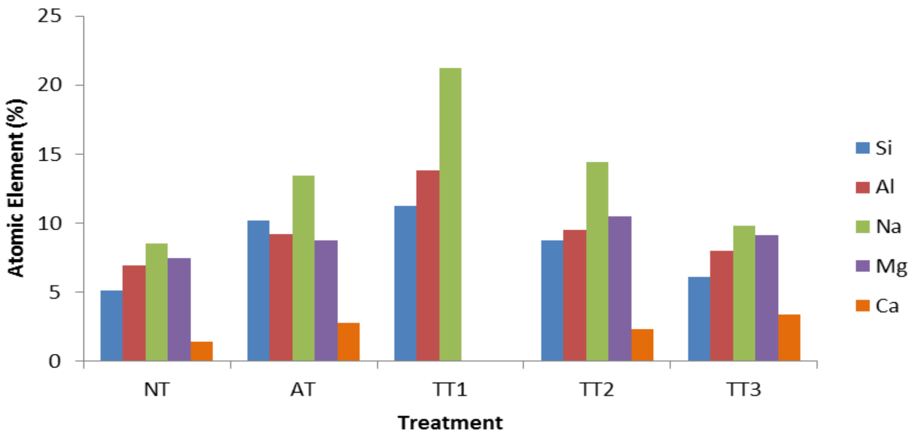


Figure 5: EDS test result

Figure 5 Shows the NT treatment to AT, the Silicon (Si) element, aluminum (Al), Sodium (Na), magnesium (Mg) and calcium (Ca) percentage rise. On the other hand it is detected a clean of dirt and a loss of chlorine element, Sulfur, Phosphorus and Scandium. Later on the TT1 treatment, element Si, Al and Na percentage rise steadily and it is the highest result from all treatments, the other elements are gone and are not detected. On the further TT2 and TT3 treatmentthe elements Si, Al and Na was dropped continuously significantly but Mg and calcium reappear. It is indicated that on the TT2 and TT3 treatment the fiber has already saturated. So it could be concluded that TT1 treatment is the best.

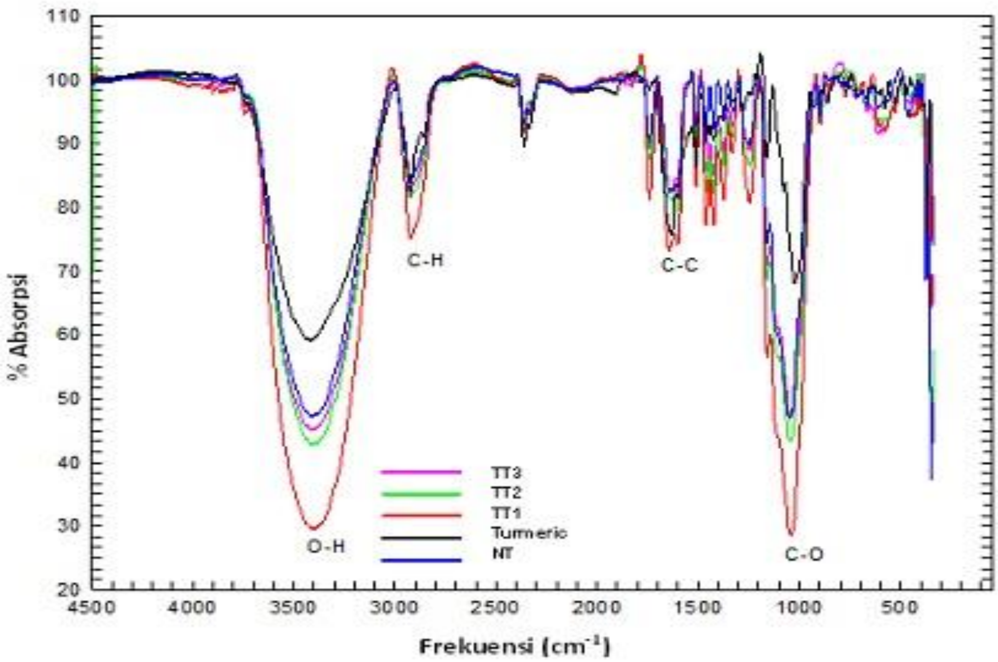
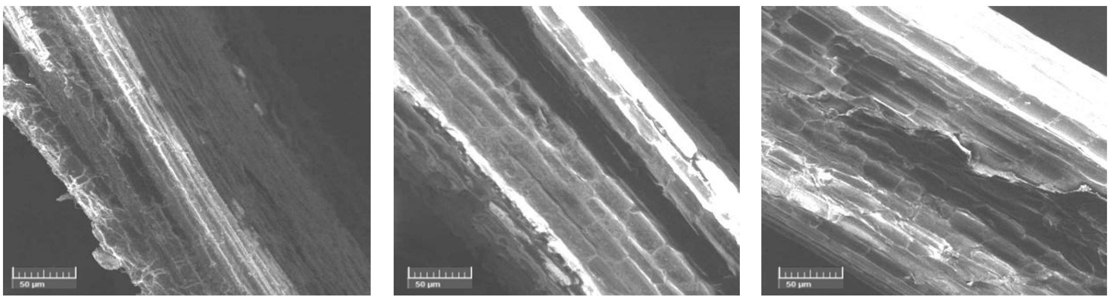
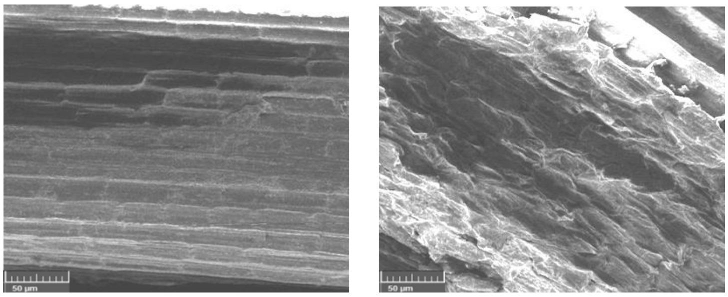


Figure 6: NT, TT1, TT2, TT3 FTIR Result [19]

Figure 6 is a graph of the Akaa fiber vibrational band FTIR test results. It is seen that there is no shifting wave number or frequency on the TT1, TT2 and TT3 treatment in the CO, C-C, C-H, and O-H area. However, the treatment with time-varying would greatly affect the Akaa fiber absorption ability. It is clear that the longer the soaking time, the higher the Akaa fiber absorption ability increased significantly at all vibrations tape. This shows that the soaking time would raise the Akaa fiber density significantly. So that it is clearly seen that the highest fiber absorption ability appears on the TT1 treatment.



(a) (b) (c)



(d) (e)

Figure 7: (a) Untreated Fiber NT, (b) AT treatment (c). TT1 treatment, (d) TT2 treatment, (e) TT3 treatment

Figure 7 shows the Akaa fiber morphology and topography SEM result for treatment NT, AT, TT1, TT2 and TT3. The TT1 and TT2 treatment produces the best fiber morphology. These treatmentshave the maximum time for the Akaa fiber cells to absorb various oxide atoms contained in the solution. Where at the beginning of TT2 treatment fiber cell erosion appears and on the TT3 treatment it is seen a number of fiber cells damaged (soluble). The Akaa fiber oxide absorption ability decreases. The fiber topography appears to be damaged, fragmented and the fiber morphology is no longer homogeneous. Topography and morphology play a role as a determinant of fiber mechanical properties such as stress and strain. It looks that under the TT1 treatment the fiber result is the best as well as from the pull out test the TT1 fiber result has the highest shear strength.

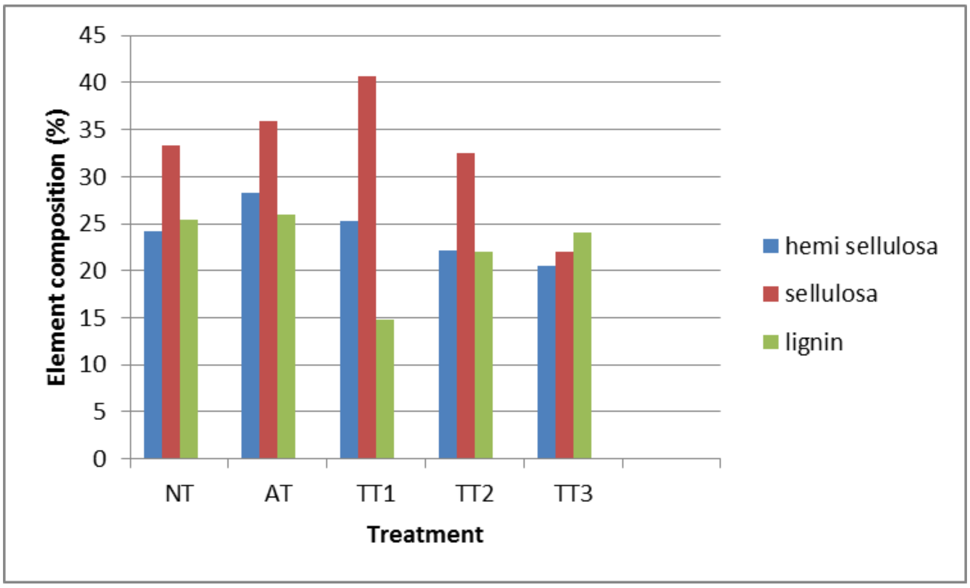


Figure 8: Result of element composition

Figure 8 shows the Akaa fiber NT treatment hemicellulose composition is about 24.12% and would then increase on the AT treatment as big as 28.24%. And down continuously on the TT1 treatment become 25.32%, on the TT2 become 22.12% and on the TT3 become 20.55%. For the cellulose composition on the NT it is about 33.28%, and would grow up to the AT as big as 35.95% and rose again on the TT1 as big as 40.61%. So the highest cellulose appears on the TT1 treatment because it declines further on the TT2 treatment as big as 32.55% and 31.77% on the TT3 treatment. Furthermore, for the lignin composition under the NT treatment is about 25.40% and about 25.89% on the AT treatment.On the next treated for 1 hour soak in the boiled turmeric TT1, the lignin composition drastic down to 14.82% or dropabout 43%. On the TT1, the lignin composition is the lowest compared with the lignin composition on TT2 which is 21.95% and TT3 which is 24.10%. So it can be stated that the TT1 has the best treatment because it has the highest hemicellulose and cellulose percentage and has the lowest lignin percentage.

CONCLUSION

Based on the previous description about natural ingredient treatment such as turmeric solution to the sheath Akaafiber it can be concluded that:

1. Turmeric treatment could affect the Akaa fiber IFSS on the epoxy matrix.
2. Turmeric treatment could change the wettability angle contact between the fiber and matrix.
3. On the TT1 treatment which is boiling the fiber for 1 hour in turmeric solution result the highest IFSS which is as big as 29.48 N/mm^2.
4. The fiber treatment on boiling the fiber in a turmeric solution for 1 hour gives the best fiber wettability, fiber morphology and fiber surface topography.

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