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International Conference on Informatics, Technology and Engineering IOP Conf. Series: Materials Science and Engineering 703 (2019) 012030 IOP Publishing doi:10.1088/1757-899X/703/1/012030 1 Tensile Properties of Kenaf Fiber by Alkalinization Treatment: Effect of different concentration Ismojo1,2, K A Zahidah1, E Yuanita1, E Kustiyah1,3 and M Chalid1* 1Department of Metallurgy and Materials Engineering, Universitas Indonesia, UI Depok New Campus, Depok 16424, West Java – Indonesia 2Department of Automotive Mechanical Engineering diploma III, Institut Teknologi Indonesia, ITI, South Tangerang, Serpong, Indonesia.

3Chemical Engineering, Universitas Bhayangkara Jakarta Raya 2nd Campus, Bekasi 17121, West Java – Indonesia E-mail : chalid@metal.ui.ac.id Abstract. The structure that plays an important role in the mechanical properties of natural fibers that will be used as reinforcement in polymer composites is crystalline cellulose.

Chemical treatment is one method that is currently widely used for modifying the chemical composition of natural fibers to obtain fibers with high crystalline cellulose content. In this study, alkali treatment with variations in NaOH concentration was used to modify the surface of kenaf fibers. The effect of alkalinization treatment on the tensile properties of kenaf fibers has been carried out.

The fiber is soaked in a sodium hydroxide solution with variations in concentrations of 4, 6, 10 and 15% by weight for 3 hours at room temperature and continued with the washing and drying process. Samples were then tested by tensile testing and characterized by using FTIR and FE-SEM instruments. Tensile testing of untreated and treated fiber is carried out 5 times for each variable.

Based on the results of these experiments showed an increase in tensile strength of all treated fibers compared to untreated fibers and the highest maximum tensile strength was obtained from the treatment of alkalinization of fibers at a concentration of 10%. This result was also confirmed by the results of FTIR and FE-SEM characterization which have shown a decrease in amorphous content in kenaf fibers and fibrillated bundle fibers into fiber elements. 1.

Introduction At present, natural fiber is the center of attention as a substitute for reinforcing materials in polymer matrices, replacing synthetic fibers such as glass fiber, because it has several advantages, namely light, abundant, recyclable and environmentally friendly. Also, natural fiber is safe for process equipment, health and cheap [1,2].

Industry that considers the use of natural fiber as a reinforcing material replacing glass fiber and carbon is the transportation industry [2]. The use of natural fibers as reinforcing materials on synthetic polymer matrices has been applied to the automotive industry, but the application is still limited to the interior [3].

Among various types of natural fiber, Kenaf fiber (Hibiscus cannabis, L family Malvaceae) is one of the natural fibers that is a concern because of its rapid growth over a wide range of climatic International Conference on Informatics, Technology and Engineering IOP Conf. Series: Materials Science and Engineering 703 (2019) 012030 IOP Publishing doi:10.1088/1757-899X/703/1/012030 2 conditions [4] and low cost [2].

In general, natural fiber consists of three main components, i.e. lignin, hemicellulose, and cellulose, which bind to each other in the form of bundles of fibers. The mechanical properties of natural fibers are largely determined by the amount of cellulose content because cellulose has a semicrystalline structure while lignin and hemicellulose are amorphous. The higher cellulose content, mechanical properties of the fiber will be increased.

Several options, including chemical treatments of natural fibers, are used to increase the crystalline portion of natural fibers and remove amorphous portions [4,5] Alkali treatment, also known as mercerization, is one of the most widely used chemical treatments, to modify the surface of natural fibers because the process is simple and inexpensive. M. Suhairil Meon et al.

Reported that the tensile strength of kenaf fiber tensile strength increases with increasing concentration of the NaOH solution [6]. B. Ahmed Amel et al. also researched kenaf fibers and reported that the tensile strength of kenaf fibers treated by 5wt%

NaOH was higher than that of untreated fibers [7]. While Y Cao et al. shows the tensile strength of kenaf fibers with an alkaline treatment, 5% higher than without treatment and decreases at 10% and 15% [8].

The main objective of this research is thus to study the effect of alkali treatment on tensile properties and changes in chemical composition in kenaf fiber. Kenaf fiber obtained from the Bonorowo area, Jepara district, Central Java, Indonesia were treated with various concentration and tensile properties were investigated. To clarify changes in the resulting tensile properties, FT-IR and FE-SEM were used to investigate changes in compound composition and morphology of kenaf fibers from alkali treatments. This result is expected can be explored the potential of kenaf fibers to be used as a candidate reinforcing material in polymer composite.

2. Materials and experimental work 2.1. Materials Kenaf fiber was obtained from the bast of the plant in Bonorowo, Jepara Regency, Central Java, Indonesia. The fibers were cleaned, washed and dried using a hairdryer. After dried, kenaf fibers were cut to 5 - 7 mm in length. 2.2. Chemical treatment of kenaf fibers The kenaf fiber, which was prepared previously, was made in three different aqueous NaOH solutions (4, 6, 10 and 15 wt%) for 3 hours at ambient temperature. After being alkalized, kenaf fibers were washed several times until neutral with distilled water and dried using solar heat. 2.3.

FT-IR measurement Changes in the composition of compounds from treated fibers are compared with Fourier transform infrared spectra (Perkin-Elmer FTIR spectrometer) 2.4. Tensile strength of kenaf fibers. The tensile testing of the alkaline treatment with different aqueous NaOH fibers was performed using UTM (Universal Tensile Machine) tensile testing machine by ASTM D1708-02 standard with a tensile speed of 100 mm/minute. 2.5.

Morphology examination The surface of kenaf fiber without treatment and alkali treatment results were examined by field scanning electron microscope (FE-SEM - FEI Inspect F50). All characterizations and testing were carried out in Metallurgy and Materials Engineering Department, Universitas Indonesia. International Conference on Informatics, Technology and Engineering IOP Conf. Series: Materials Science and Engineering 703 (2019) 012030 IOP Publishing doi:10.1088/1757-899X/703/1/012030 3 3. Results and discussion 3.1.

Chemical composition Fourier Transform Infrared spectroscopy was used to investigate changes in the composition of compounds in kenaf fibers after undergoing alkali treatment with different NaOH concentrations. FTIR spectra of untreated kenaf fibers and alkali treatment results are shown in Figure 1. From figure 1 (KV), it can be observed that untreated kenaf fibers show peaks at around 3335, 2894, 1731, 1594, 1423, 1160, dan 897 cm-1.

Peaks at 3335 cm-1 and 2894 cm-1 indicated O – H stretching vibrations and the hydrogen bond of the hydroxyl groups and C–H stretching of cellulose, hemicelluloses, and lignin, respectively [9,10]. The peak on 1731 cm-1 indicated the C=O stretching vibration of the acetyl groups in the hemicelluloses and lignin [8]. The peaks at 1594 dan 1423 cm-1 represents C=C stretching of the benzene ring of the lignin [10,11].

Another peak at 1160 cm-1 is a characteristic band for C – O stretching modes and C – O – C stretching vibration of cellulose, hemicelluloses, and lignin [10]. The final peak at 897 cm-1 is associated with the C – H of ß -glycosidic linkages between the monosaccharides of Cellulose [9]. Figure 1. IR Spectra of untreated and treated kenaf fibers.

Fourier Transform Infrared spectroscopy was used to investigate Compared with the peak of kenaf fiber the result of the treatment of alkalinization at 10 wt.% NaOH, the peak at 1731 cm-1 is no longer visible. This indicates that part of lignin was removed from kenaf fibers after alkali treatment. While the peaks at 1594, 1423, 1160, and 897 cm-1 increase in transmission values which indicate a reduction in the molecules at the peak decreases.

From these results, it can be concluded that alkaline treatment, causes loss of binding materials, such as hemicellulose, lignin, and amorphous cellulose, and increase the crystalline portion. While the loss of learning content in kenaf fibers due to the influence of the concentration of NaOH solution can be seen in Fig. 2. International Conference on Informatics, Technology and Engineering IOP Conf. Series: Materials Science and Engineering 703 (2019) 012030 IOP Publishing doi:10.1088/1757-899X/703/1/012030 4 Figure 2. Effect of alkali treatment concentration on relative content of lignin 3.2.

Tensile strength One of the factors that influence the mechanical properties of natural fibers is the content of cellulose contained in and natural because cellulose has a semicrystalline structure while lignin and hemicellulose have an amorphous structure. The effect of the alkali treatment concentration is shown in Figure 3. From that figured, it was shown that the alkali treatment can increase the tensile strength of kenaf fibers when compared to untreated kenaf fibers.

These phenomena occur because during the alkali treatment the amorphous content in kenaf fibers is reduced and Cellulose crystalline increased. The maximum value of the tensile strength of kenaf fibers was obtained in alkali treatment with a concentration of

10 wt.%. While on treatment alkalinization with a concentration of 15 wt.% NaOH, kenaf fiber tensile strength decreased.

This phenomenon can be explained by the fact that during the treatment of alkali at that concentration a portion of the crystalline cellulose molecular chain of the kenaf fiber is broken and reduced. The reduced crystalline portion of the fiber causes the tensile strength decreased and this result is in line with the data shown in Figure 2 and the study has been reported by Y. Cao et.al. [8]. International Conference on Informatics, Technology and Engineering IOP Conf.

Series: Materials Science and Engineering 703 (2019) 012030 IOP Publishing doi:10.1088/1757-899X/703/1/012030 5 Figure 3. Tensile strength of untreated and treated kenaf fibers. 3.3. Morphology SEM images in Fig. 4 & Fig 5 shows the untreated kenaf fiber and treated fiber through alkali treatment with 10 wt.% NaOH. From Fig.

4 it can be seen that kenaf fibers are still in a bundle or fused state and there are many impurities. While the fiber results in an alkalinization treatment (Fig. 5) fibrous kenaf fibers with a clean surface appearance. The fibrillated of kenaf fibers shows binding materials such as lignin and hemicellulose are removed after alkali treatment and bundle fibers break down into separate fiber elements. This result is under the results obtained from FTIR testing. Figure 4. SEM imange of untreated kenaf fiber (kenaf virgin;KV) Figure 5.

SEM imange of alkali- treated kenaf fiber with 10 wt.% NaOH 4. Conclusion The effect of alkali concentration on the mechanical properties of kenaf fibers was discussed in this study. Alkali treatment, causes the kenaf fibers to become fibrillated and the amount of cellulose increases with the loss of amorphous content such as lignin and hemicellulose.

Increasing cellulose content in fiber caused the tensile properties of kenaf fibers to increase and the maximum yield was obtained in alkali treatment with a concentration of 10 wt.% NaOH. International Conference on Informatics, Technology and Engineering IOP Conf. Series: Materials Science and Engineering 703 (2019) 012030 IOP Publishing doi:10.1088/1757-899X/703/1/012030 6 Acknowledgments We appreciate and thank you for the support from DRPM UI through its program PIT9 Grant Scheme Which makes this research possible.

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