IOP Conference Series: Materials Science and Engineering

PAPER • **OPEN ACCESS**

Effects of alkali and steaming on tensile strength of aren (*arenga pinnata*) fiber

To cite this article: S Darmanto *et al* 2019 *IOP Conf. Ser.: Mater. Sci. Eng.* **508** 012071

IOP Conf. Series: Materials Science and Engineering **508** (2019) 012071 doi:10.1088/1757-899X/508/1/012071

Effects of alkali and steaming on tensile strength of aren (*arenga pinnata*) fiber

S Darmanto*, S Sugeng, Indartono and E J Sasono

Program Studi Sarjana Terapan, Rekayasa Perancangan Mekanik, Sekolah Vokasi, Universitas Diponegoro, Semarang 50256, Indonesia

*senodarmanto@gmail.com

Abstract. The aim of this research is to investigate the alkali treatment and steaming influence on mechanical properties of Aren frond fiber. The presence of surface impurities and the large amount of hydroxyl groups makes natural fiber less compatible for composite materials reinforcement. Effort to remove the impurities can be done by few treatment that consist of physical, chemical and mechanical treatment. First, Aren frond single fiber were subjected to alkali treatments with 1%- 5% NaOH for a period of 4 - 7 hours to room temperature and followed by steaming 1 - 2 bar in pressure. Treatment of alkali and alkali-steaming combination can increase cellulose content. The tensile tests showed that the alkali and steaming treatment combination resulted the highest tensile strength of Aren frond fiber by 512 MPa. Then the impurities in surface fiber single effect interfacial stress and tend decrease bonding strength. These results show that the combination of alkali treatment and steaming can increase mechanical properties of Aren frond fiber.

1. Introduction

Natural fibers including Aren and the like without treatment have technical strength such as tensile strength, fracture stretch, toughness tend to be low and high water absorption. Fiber quality will tend to decrease sharply when fiber is in dry conditions where a decrease in tensile strength and an increase in brittle properties are more dominant. And due to the high water absorption properties, the strength of natural fiber techniques also tends to decrease. Increasing the quality value of Aren fiber and the like can be done by processing raw Aren fiber and the like to a single fiber accompanied by treatment. There are several basic stages of processing natural fibers into single fibers including the manufacture of single fibers (cutting, rolling and separating), pre-treatments (separation of impurities, washing and drying), further separation (fibers against corks, adhesives and tannins) and final treatment (physical, chemical and mechanical). Management of agricultural natural fiber in Indonesia is still largely at the level of initial treatment and applied to the people's handicraft industry. The application of natural fibers in the form of a single fiber has begun to develop in the traditional bag and fabric handicraft industry with prices that are still relatively expensive due to the cost of procuring a difficult and expensive single fiber.

In the short term, the limitations of natural fibers on a micrometre scale, especially in terms of the quality of natural fibers and applications for bio composites, can be improved both in the processing stage, the formation and diversification of product applications. And for the long term, the development of natural fibers on the nanometre scale will produce finished products in the automotive field (filters, exterior interiors), medical (teeth, skin, and bone), electronics (screens, insulators) and environmentally friendly products as well as providing raw materials for bio composite products and biofuels (bioethanol). Natural fiber research as an advanced material for health and medicine research is more focused on the biomedical field. Several biomedical studies have developed artificial materials including skin, teeth and gums based on natural fibers, especially cellulose on a nanometre scale. Future research on Aren fiber is focused on alkali and steaming treatments to improve the mechanical properties of micrometre-scale fibers.

2. Material and Method

The main material was prepared consisting of Aren frond, NaOH and distilled water. Further there are several tools used in the study including fiber processing, early treatment, physical treatment, chemical treatment and the manufacture of the specimen. Fiber processing equipment consists of saws, knives, scissors, coarse steel brushes, smooth steel brushes, rolling and dryer. Then physical treatment equipment consists of a stainless steel pan, square-shaped glass vessels of various sizes, heating, and steaming. Then the equipment for the chemical treatment includes saw, beaker glass, measuring cup, a square-shaped glass vessels of various sizes, glass bowl, a small pan, stirrer, heater and temperature measuring devices. Furthermore, equipment of making specimens consists of cardboard, scissors, knives, steel ruler, and adhesives.

First, the Aren frond is broken down into a bundle fiber. Bundle fiber fibrillation was done through several stages of work includes the selection frond, cutting to size 50 cm, cleavage, soaking, drying, brushing and the separation of a bundle fiber to the other components. After soaking with distilled water and forced drying in an oven, the fiber then has been steamed at a pressure of 1 bar for 60 minutes.

The mechanism of alkali treatment was done through several stages including the preparation of fiber, the preparation of sodium hydroxide solution with 1%- 5% NaOH, dipping the fiber during 4 hours and 7 hours, forced drying of the fiber and fiber storage. The fiber then was steamed up to a bundle fiber by passing the saturated vapour pressure at 2 bars and hold for 60 minutes.

Density of the untreated and treated Aren frond fibers was measured according to the ASTM D 3800-99 standard test method. Mercury was used as immersion liquid. The density of the fiber (ρ_f) was calculated using the following equation.

$$\rho_f = \frac{W_{fa}}{W_{fa} - W_{fl}} \rho_l$$

where ρ_l is the density of mercury liquid (13,6 g/cm^3), W_{fa} is the weight of fiber in air and W_{fl} is the weight of fiber in liquid.

The fiber bundle tensile test of Aren frond fibers was calculated according to ASTM D3379 standard. Tensile test was performed using a mersdan lab machine with the crosshead speed of 5 mm/min.

3. Result and Discussion

Aren fronds in principle consist of stems and leaves. Aren frond bundle fiber shows a fiber variation both colour and dimension. Bundle fiber of Aren frond consists of 3 categories namely smooth/fine, rough/coarse and soft (Fig. 1). Fine bundle fiber has a cream-brown and black color and is predominantly cream- brown. Then coarse bundle fiber has a black colour and it is difference with soft bundle fiber ie. cream. Furthermore, fine and coarse fibers tend to be long, while soft fibers have a short size. Based on observations with a microscope, the diameter of fine fibers averages 50 µm. Furthermore, coarse fiber and soft fiber have an average diameter of 340 µm and 470 µm respectively.

IOP Conf. Series: Materials Science and Engineering **508** (2019) 012071 doi:10.1088/1757-899X/508/1/012071

Figure 1. Variation of bundle fiber surface appearance

Density of bundle fiber shows a increase on treated Aren frond fibers. The density of the alkali treated fibers can reach at the highest at 0,54 gram/cm^3 which it is higher than 0,34 gram/cm^3 for untreated fibers. This may correspond with reduction impurities such as hemicellulose, lignin, pectin, and waxes. Alkali treatment of Snake Fruit frond fiber reduced hemicellulose percentage [1] [2]. Density of fan palm fibers has a trend to increase after treatments the alkali treated [3]. The decrease of hemicellulose (the increase in α-cellulose content) after treatment was also believed to be responsible for the increased density [4]. The density of hemp fibers increased after several chemical treatments including alkaline, acetic anhydride, maleic anhydride and silane [5].

Alkali treatments affect the mechanical properties of the Aren frond fiber. It was noted that increasing alkali contents of the solution are not always increasing the fiber tensile strength. As shown in Fig. 2, the tensile strength increases with increasing at 2% of alkali contents. However, a further increase in alkali contents results in decreasing tensile strength. Therefore the percentage of 2% is the optimum value for this case. The tensile strength, starting from 178 MPa before treated, increases as high as 520 MPa with the treatments. The soaking time also influences the tensile strength. As shown in Fig. 2, the treatment in 4 hours gives a higher strength compared to that of 6 hours. The tensile strength of snake fruit show optimun point at 2% of alkali by reaching 275 MPa [2]. The level difference of alkali is showed on fan palm fiber treatment by achieving 816 MPa for 4% of alkali concentration [3].

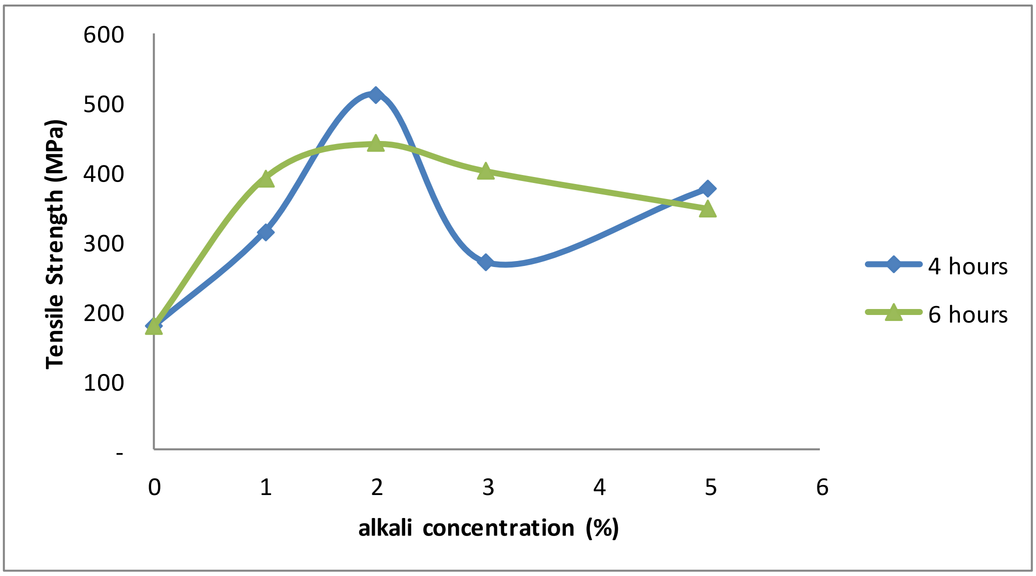

Figure 2. The effect of alkali treatment on tensile strength

4. Conclusion

There are some treatments that consist of physical and chemical methods for reducing impurities of Aren frond fiber. Aren frond bundle fiber that subjected alkali treatments results in increasing density. Further treatment with steaming results further increases in density. Variations of alkali contents and treatment time during chemical treatment results in a fiber strength. The highest tensile strength was 520 MPa that is found at Aren frond fiber immersed in 2% NaOH for 4 hours followed by steaming.

5. Acknowledgments

This work has been supported by funding of Hibah Penelitian Dasar Unggulan Perguruan Tinggi (PDUPT) 2018, DRM Kemenristek Dikti, support for a national researcher at Universitas Diponegoro. The authors are grateful to the staff of Laboratory of Material and LPPM, Universitas Diponegoro.

6. References

[1] Darmanto, S, Heru SB Rochardjo, Jamasri, Ragil Widyorini, 2017,"*Effects of Steaming and Steam Explosion on Mechanical Properties of Snake Fruit (Salacca) Fiber*", International Journal of Engineering and Technology (IJET), Vol 9 No 1

[2] Darmanto, S, Heru SB Rochardjo, Jamasri, Ragil Widyorini, 2016,"*Effects of alkali and steaming on mechanical properties of snake fruit (Salacca) fiber*", International Conference on Engineering, Science and Nanotechnology 2016, American Institute of Physics

[3] Hestiawan, H., Jamasri & Kusmono, 2017," *Effect of chemical treatments on tensile properties and interfacial shear strength of unsaturated polyester/fan palm fibers*", Journal of Natural Fibers, Volume 15, Issue 5

[4] Mwaikambo, L. Y., and M. P. Ansell. 2006. "*Mechanical properties of alkaline treated plant fibers and their potential as reinforcement materials. I. hemp fibers*". Journal of Materials Science, **41**: 2483-2496.

[5] Sawpan, M. A., K. L. Pickering, and A. Fernyhough. 2011." *Effect of various chemical treatments on the fiber structure and tensile properties of industrial hemp fibers*". Composites Part A: Applied Science and Manufacturing, **42**: 888-895.