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Effect of Microwave Treatment on Mechanical Properties of Coir Fibers

B Bakri¹, Naharuddin¹, A E E Putra², I Renreng², H Arsyad², A A Mochtar²

¹Mechanical Engineering Department, Engineering Faculty, Tadulaku University, Jl Soekarno Hatta km.9, Palu, Indonesia, 94118

²Mechanical Engineering Department, Engineering Faculty, Hasanuddin University, Jl. Poros Malino Km.6, Bontomarannu, Gowa, Indonesia
Email: bakri@untad.ac.id

Abstract. This paper investigate the effect of microwave treatment of coir fibers on mechanical properties (including tensile strength and strain) and surface morphology as well as crystallinity index. Coir fibers were exposed on the microwave oven for 10, 20, and 30 minutes. Characterizations of raw and microwave treatment of fibers were conducted with tensile testing, scanning electron microscopy (SEM) and X-ray diffraction (XRD). The results showed that tensile strength of coir fiber after microwave treatment for 10 minutes was higher than raw and other treatment. Meanwhile, strain tended to decrease after microwave treatment. Surface morphology of coir fiber was found change after treatment. In addition, the crystallinity index of coir fiber tends to decrease after treatment.

Keywords: effect, microwave treatment, coir fibers,

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1. Introduction

Natural fibers have been used as reinforcement of composite in the last decade. They have advantages compared to synthetic fibers like low cost, lightweight, environmentally friendly, and biodegradable [1,2]. But, they have the problem when composed of the synthetic polymer. Compatibility between fiber-matrix is a drawback of natural fibers as reinforcement because natural fibers are hydrophilic and polymers are hydrophobic in nature. To anticipated this problem, surface treatment of natural fibers have been done by researchers such as chemical [3-5] and physical treatment [5,6].

Coir fiber is one of the natural fibers which has been used as reinforcement of composite. The tensile strength of coir fiber is relatively low compared with other natural fibers but it has higher elongation [7,8]. Chemical treatment (such as alkali, silane) of coir fiber improve adhesion of fiber-matrix [9, 10]. In alkali treatment, removing lignin and impurities, depolymerization of cellulose structure and change of crystallites of natural fibers occur [11]. Then, physical treatment of coir fibers has been conducted Praveen et al. [12] by using plasma treatment. The topography of coir fiber after plasma treatment appears difference of raw coir fiber and also show etching of fiber wall. Another treatment of natural fiber is irradiation microwave [6]. Microwave treatment process is a shorter time than chemical treatment. It uses radiation energy for exposing substances of natural fiber by heating the environment. Lignin, wax and surface impurities can be removed after microwave treatment [6]. Then, microwave treatment of empty fruit bunch (EFB) fiber has been done by Islam et al. [6] where EFB fiber was soaked in alkali solution (12.5%) with different temperature and different time. Mechanical and thermal properties of fiberbased composite increase after microwave treatment of EFB fiber. This treatment was also used [12], the dyeing of wool fabrics which show that after treatment, wool fabrics dyeability was improved [13].

The purpose of this paper is to investigate the influence of microwave treatment on mechanical properties, surface morphology and crystallinity index of coir fibers. The microwave treatment was conducted to coir fiber without the combination of chemical solution. The characterization of coir fiber before and after microwave treatment was carried out using tensile testing, scanning electron microscopy (SEM), and X-ray diffraction (XRD).

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2. Methodology

Coir fibers were extracted from coconut husk. They were washed with water to remove surface impurities. After that, coir fibers were dried in temperature room during 48 hours. Coir fiber after drying was treated using irradiation microwave. To understand the influence of microwave treatment, coir fiber was exposed in the microwave oven at different times including 10 minutes (M10), 20 minutes (M20) and 30 minutes (M30). The microwave oven was set at 100% power for all samples.

Characterizations of coir fiber include tensile testing, scanning electron microscopy (SEM) and X-ray diffraction (XRD). Tensile testing of coir fiber was conducted to know mechanical properties of coir fiber. Universal Testing Machine – Llyod L10K Plus was used for tensile testing and based on ASTM 3379. The gauge length of fiber specimen was 30 mm and strain rate was set at 2.5 mm/min.

Surface morphology of coir fiber was characterized with SEM – JEOL JSM 6510 LA. Then, XRD analysis was used to determine crystallinity index of raw and microwave treatment of coir fibers. XRD-7000 X-Ray Diffraction SHIMADZU was used in this analyses. To calculate crystallinity index (CI), Segal method is used as in (1)[14] :

$$CI(\%) = \frac{I_{002} - I_{am}}{I_{002}} \quad (1)$$

where I_{002} is the maximum intensity diffraction of the peak and I_{am} is the minimum intensity diffraction of the peak.

3. Results and discussion

3.1. Mechanical Properties

Mechanical properties of coir fiber before and after microwave treatment can be seen in figure 1 and figure 2. In figure 1, the tensile strength of raw coir fibers is 142.40 MPa and microwave treatment of coir fiber for 10 minutes (M10) in the microwave oven is 187.25 MPa. M10 sample has higher tensile strength compared with other samples. This may remove lignin, wax and other impurities [6] which improve tensile strength of fiber. Then, the strain of coir fiber can be seen in figure 2 where after microwave treatment, the strain of coir fiber tends to decrease compared with raw coir fiber.

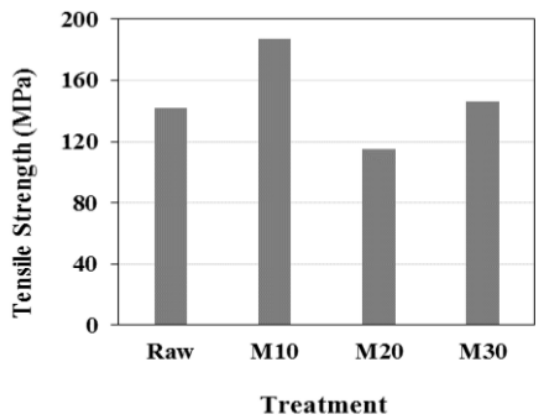


Figure 1. Tensile strength of coir fiber before and after microwave treatment

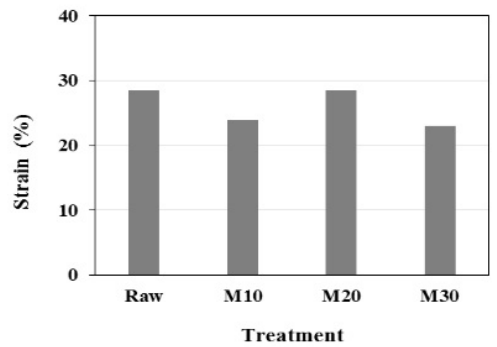


Figure 2. Strain of coir fiber before and after microwave treatment

3.2. SEM characterization

Surface morphology of coir fiber can be analyzed by SEM as shown in figure 3. Raw and microwave treatment of coir fibers show the difference of surface where M10 and M20 samples were found rougher than raw coir fiber as shown in Fig. 3. This is caused by exposing coir fiber in the microwave oven. The rougher surface of coir fiber may correspond to the tensile strength of coir fiber after microwave treatment for 10 minutes (M10 sample). This may also improve the fiber adhesion with matrix [15].

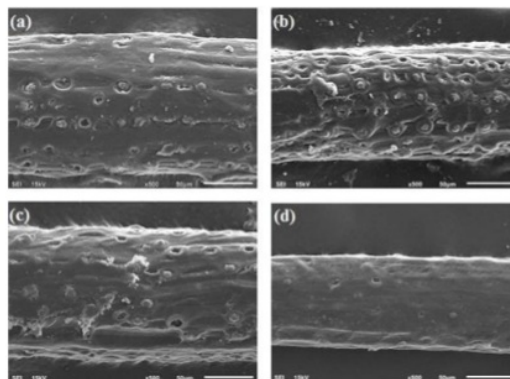


Figure 3. SEM of coir fibers (a) Raw, (b) M10, (c) M20 and (d) M30

3.3. XRD characterization

Figure 4 shows X-Ray diffraction of analyses of raw and microwave treatment of coir fibers. From figure 4 and table 2, crystallinity index (CI) of coir fiber after microwave treatment fluctuated. In addition, after exposed 10 and 20 minutes in the microwave oven, the crystallinity index decreased. Meanwhile, the CI of microwave treatment for 30 minutes was relatively similar to raw fiber. Raw

coir fiber crystallinity index in this paper is 35.02% which is smaller than result from researchers i.e. 57%[16] and 60.14%[17].

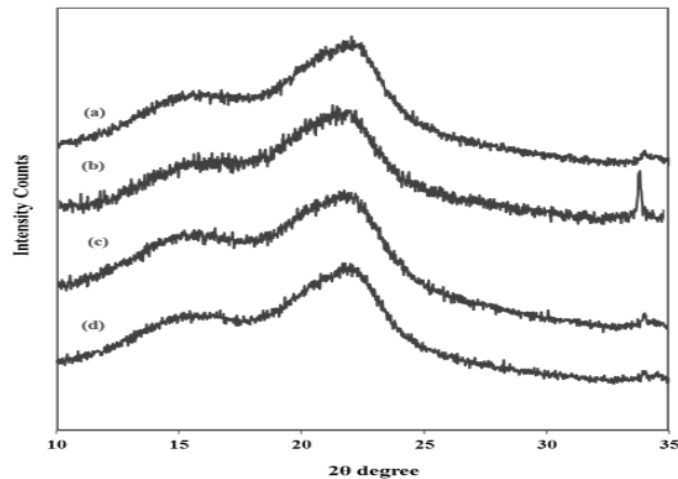


Figure 4. XRD of coir fibers (a) Raw, (b) M10, (c) M20 and (d) M30

Table 1. Crystallinity index (CI) of coir fibers

Samples	Crystallinity Index, CI (%)
Raw	35.02
M10	34.66
M20	29.70
M30	35.26

4. Conclusions

The characterizations of coir fiber before and after microwave treatment using tensile testing, SEM and XRD show that the tensile strength of coir fiber after microwave treatment for 10 minutes increase, meanwhile strain to fracture of coir fiber relatively decrease after treatment. Then, the surface morphologies after treatment for 10 and 20 minutes of coir fiber were found rougher than raw fiber. In addition, the crystallinity index of coir fiber decreased after microwave treatment for 10 and 20 minutes.

5. Acknowledgments

The authors are thankful to Ministry of Research, Technology and Higher Education for the financial grant to support this research work. The authors would like to thank Mechanical Engineering department Hasanuddin University for collaboration of research. Also, the authors would like to acknowledge the SEM Laboratory FMIPA-ITB, Material Laboratory Makassar Academy of Industrial Engineering and Research and Science Development Laboratory FMIPA Hasanuddin University.

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