

Influence of Alkali And Microwave Treatments of Fiber on The Water Absorption And The Mechanical Properties of Coir Fiber/Polyester Composites

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Abstract— In this study, coir fibers were surface treated with alkali and microwave treatments. The effect of alkali and microwave treatments of coir fibers as reinforcement of coir fiber/polyester composite on water absorption and mechanical properties (tensile, flexural and impact strength) was reported. Treatments were divided into two types: microwave treatment of coir fibers for 10 minutes (M10) and 20 minutes (M20) without alkali treatment; and alkali treatment of coir fibers with soaking during 24 hours in 5w/v% NaOH solution, followed by heating in the oven for 2 hours (2N) and also followed by microwave treatment during 10 minutes (NM10) and 20 minutes (NM20). Coir fiber then was pressed like mat which was used as reinforcement of polyester composite. Hand lay-up technique with compression molding was used to fabricate composite. The water absorption and mechanical properties like tensile strength, tensile modulus, flexural strength and impact strength were studied. Fracture of tensile testing was evaluated by Scanning Electronic Microscopy (SEM). The results obtained showed that alkali and combination of alkali and microwave treatment improved significantly the water absorption of the composite. For mechanical properties of the composite, alkali and microwave treatments of coir fiber tend to increase tensile strength, tensile modulus, flexural strength and impact strength. However, for both M10 and NM20 treatments, the flexural strength of composite decrease due to the poor adhesion between fiber and matrix in the composite. Then, SEM characterizations show treated fiber improved the adhesion fiber-matrix in the composites.

Keywords— coir fiber, alkali, microwave treatment, water absorption, mechanical properties

I. INTRODUCTION

Natural fiber polymer composites have been developed in more application. One of these is a coir fiber/polymer composite. The using of coir fiber as reinforcement of composite is interested due to its abundant and relatively low cost of production [1]. However, natural fibers have the problem while they are used as reinforcement of composite related to interfacial bonding. The less interfacial adhesion between natural fiber and polymer matrices in the composites is caused by the hydrophilic character of natural fibers. This limitation of natural fiber has been needed to search methods for improving its character. Some

researchers have investigated to increase the performance of its composite with chemical and physical surface treatment of natural fibers. The tensile strength of coir fiber/polypropylene composite has increased after the alkali treatment of coir fiber due to the improvement of compatibility between fiber and matrix [2]. Then, Rout et.al [3] investigated the effect of chemical treatment of coir fiber as reinforcement polyester composite on tensile, flexural and impact strength. That result shows the mechanical properties like tensile, flexural and impact strength of coir/polyester composite rise after surface treatment of coir fibers. Meanwhile, the water absorption of composite reduced on surface treatment of coir fiber. Another chemical treatment like o-hydroxybenzene diazonium salt has been used by Islam et.al [4] for surface treatment of coir fiber as reinforcement of polypropylene composite. Improving mechanical properties and water absorption behavior of coir/PP composite was achieved after o-hydroxybenzene diazonium salt treatment of coir fibers. For physical treatment of natural fiber for reinforcing composite, plasma treatment of sisal fiber increased the performance of sisal/polypropylene composite [5]. Then, irradiation microwave treatment has been used by Islam et al. [6] to modify the empty fruit bunch (EFB) fiber for reinforcing composite. The mechanical and thermal properties improved due to treatment. The treatment of EFB also altered the water absorption of the composite. The content of moisture absorption on composites influences on the mechanical properties and also physical properties [7].

The focus of the present research work is to study of water absorption and mechanical properties of coir fiber/polyester composite. Alkali and microwave treatment on coir fiber have been published by authors [8,9]. The effect of alkali and microwave treatments of fiber on water absorption and mechanical properties like tensile strength, flexural strength and impact strength of the composite is studied.

II. METHODOLOGY

Coir fibers which extracted from coconut husk were obtained from Tawaeli-Palu area, Central Sulawesi. Fibers then were washed and cleaned with water to remove surface impurities. Coir fibers were also soaked in sodium hydroxide (NaOH) solution 5 wt% for 24 hours. After soaking, the

fibers were rinsed and followed by drying in temperature room for 48 hours. Alkali and microwave treatment of coir fibers were performed as follow: the coir fibers without sodium hydroxide treatment were treated using irradiation microwave. Such fibers were exposed in the microwave oven at different times including 10 minutes (M10) and 20 minutes (M20)) [9]. Then, the treated coir fibers of sodium hydroxide were exposed in the microwave oven with irradiation microwave at different times (10 minutes (NM10) and 20 minutes (NM20)) without heating in the oven. Lastly, treated coir fibers of sodium hydroxide were heated in the oven for 2 hours at 100°C (2N) [8]. The setting of the microwave oven during the treatment process was 100% power.

Prior to fabrication of the composites, coir fibers were pressed like a mat (Fig.1). The polyester resin was mixed with methyl-ethyl-ketone as a catalyst. The resin was poured on the fiber mat in the mold. Hand lay-up method was applied to mold the composites using a steel plate mold followed by compression molding with the manual hydraulic press (Fig.2) until 4 ton reached. The composites were fabricated with 17% fraction volume of fibers and 83% volume fraction of polyester matrix.



Fig.1 Pressed coir fiber like mat



Fig.2 Compression molding with the manual hydraulic

The test specimen of water absorption is rectangular with dimensions of 25.4 mm wide by 76.2 mm long by the thickness of the composite. The standard test method for the

water absorption of this composite is ASTM D 570-98. The percentage of water absorption after immersion was calculated using the following equation

$$\%W = \frac{W_t - W_o}{W_o} \times 100 \quad (1)$$

where W_t is wet weight after immersion and W_o is conditioned weight.

Tensile strength and flexural strength were determined by a Universal Testing Machine -TN20MD Controlab type. The tensile test was conducted according to ASTM 638-02 and the flexural test (three-point bend) was carried out according to ASTM D 790-02. Then, impact testing was performed based on the ASTM D 256.

The tensile fracture morphology of composite was examined by scanning electron microscopy (SEM). In this study, the SEM –JEOL JSM 6510 LA type was used.

III. RESULTS AND DISCUSSIONS

Fig.3 shows the water absorption of coir fiber/polyester composite as a function of the immersion time. From Fig.1, water absorption increased quickly with immersion time for 2 days for all samples. After 2 days, water absorption tends to increase slowly caused by the equilibrium moisture content closely attained where sample absorb water. The composite with untreated (UT) fiber as reinforcement has higher water absorption than treated fiber. This case shows that the lack of bonding and wetting character between fiber and polyester matrix on untreated coir/polyester composite [3] caused capillary transport appeared at the interface fiber-matrix. The water absorption of composite showed that combination treatment alkali and irradiation microwave (NM10 and NM20) and alkali treatment only (2N) absorbed less water than untreated fiber and microwave without alkali treatment. The reduction of water absorption from untreated coir fiber/polyester composite to alkali (2N) and the combination of alkali and microwave treatments (NM10 and NM20) is 12.27% to 4.03%, 4.84%, and 4.52% respectively.

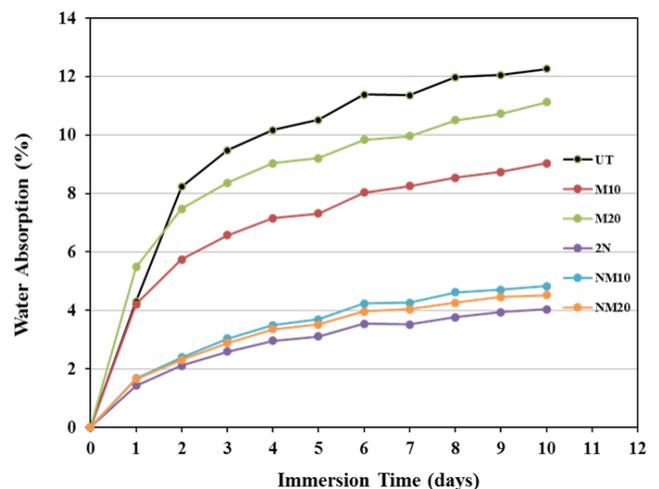


Fig.3 The immersion time effect on water absorption properties of composites

The influence of coir fiber treatment with alkali and microwave treatment on the tensile strength and tensile modulus of coir fiber/polyester composite can be seen in

Fig.4 and Fig.5. In tensile strength, the microwave treatment of coir fibers (M10 and M20) on composite is an increase slowly compared with untreated coir fibers (UT). Meanwhile, alkali treatment (2N) and alkali and microwave treatment combination (NM10 and NM20) of coir fibers increase rapidly from untreated fibers. The better bonding between fiber and matrix in the composite due to treated fiber causes the rise of tensile strength. The fiber surface treatment may lead to improvement of the interface adhesion of fiber-matrix [2,10] due to mechanical interlocking occur [3]. Likewise, the tensile modulus of composites as shown in Fig.5 raised after treated fibers. 2N and NM10 treatments of the composite have similarly tensile modulus about 348 MPa and higher than untreated fiber of composites. The higher tensile modulus of composites after fiber treatment is attributed to the higher stiffness of composites [11].

Fig.6 showed the effect of alkali and microwave treatments of coir fibers on flexural strength of coir fibers reinforced polyester composite. The flexural strength of composite increases gradually after the M20, 2N and NM10 treatments of fibers in comparison to untreated fibers (UT) of the composite. However, the flexural strength decreases for the fiber treatment of both M10 and NM20 treatments of the composite. In this case, the decrease of flexural strength may be caused by the poor adhesion between fiber and matrix in the composite. Composites with both 2N and NM10 treatments have better flexural strength than other treatments and untreated fibers.

The impact strength of coir fiber reinforced polyester composites related to the influence of alkali and microwave treatment of fibers is shown in Fig.7. All treatments of coir fibers of composite increase the impact strength in comparison to the untreated fiber of composite. As can be seen in Fig.7, NM10 treatment of coir fiber as reinforcement of composite has a huge impact strength. This may be due to good toughness behavior. The impact strength of untreated fiber reinforced polyester composite was obtained at 2.04 kJ/m², whereas NM10 treatment of fibers was found to be 8.77 kJ/m². The increase impact strength was approximately 4 times from untreated fiber.

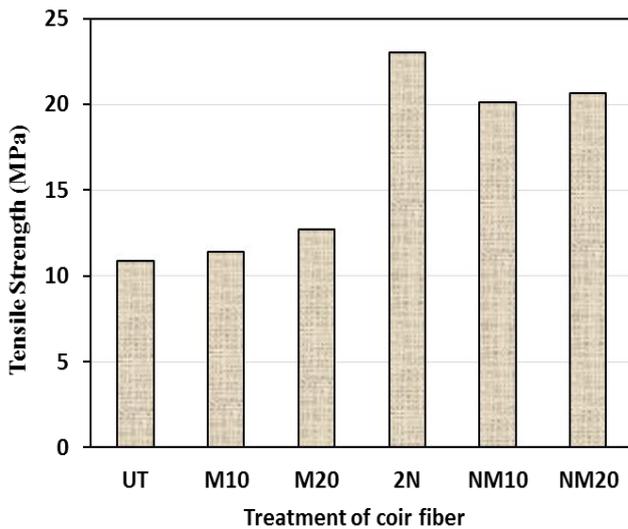


Fig.4 Effect of alkali and microwave treatment of coir fibers on tensile strength of composites

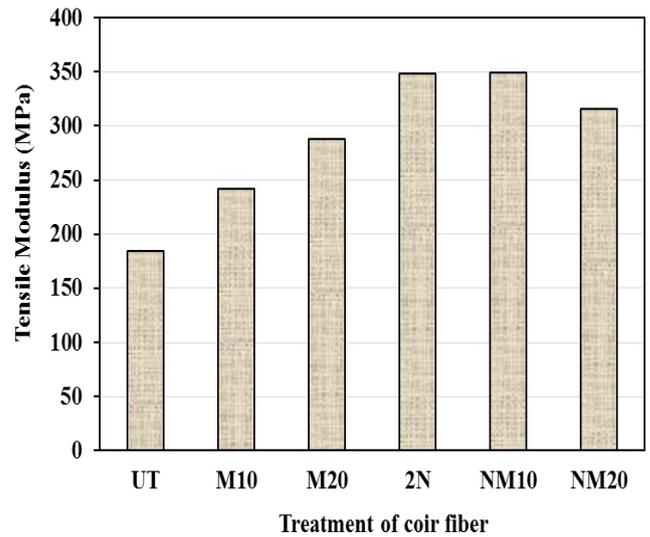


Fig.5 Effect of alkali and microwave treatment of coir fibers on tensile modulus of composites

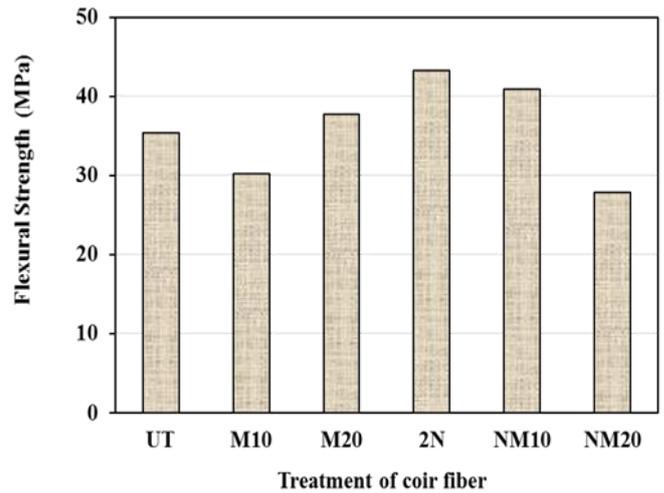


Fig.6 Effect of alkali and microwave treatment of coir fibers on flexural strength of composites

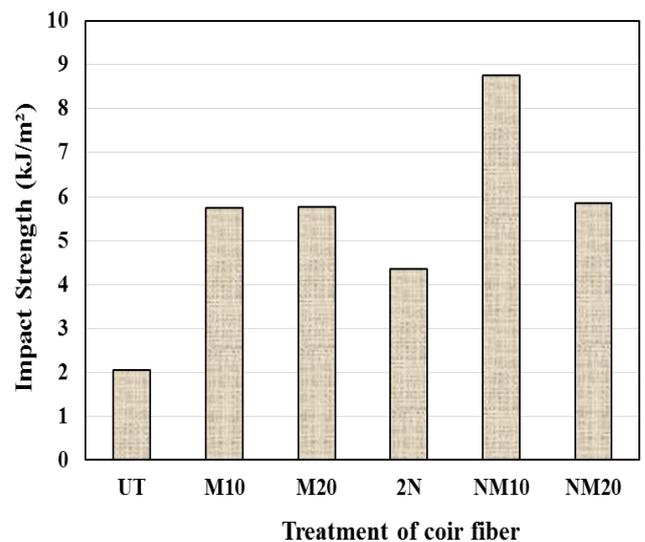


Fig.7 Effect of alkali and microwave treatment of coir fibers on impact strength of composites

SEM images of tensile fracture of coir fiber reinforced polyester composite with untreated and treated coir fibers were shown in Fig.8. The tensile fracture micrographs of SEM show fiber pull out, debonding, matrix cracking, cut-off fiber/fiber broken, strong adhesion between fiber and matrix. In Fig.8 (a), the pull out and debonding of fiber-matrix appear in the composite with untreated coir fiber as reinforcement after tensile testing. The more fiber pull outs also appears in M10 treatment (Fig.8 (b)) and M20 treatment (Fig.8(c)) of composite. These lead to reduction of tensile strength of composite. Good adhesion between fiber and matrix can occur when the fibers adhered strongly in the polyester matrix due to mechanical interlocking and also good wetting of fiber by matrix. It can be seen in composite with 2N treatment (Fig.8(d)) and NM10 treatment (Fig.8(e)) of coir fibers where some fibers were cut off or fiber broken ends which indicating to strong bonding between fiber and matrix [3]. This adhesion increases the strength of composite. In addition, when the tensile testing of composite was realized the cracking of matrix (Fig.8 (f)) can be occurred because matrix receives the load to transfer to the fiber so that it may lead to damage in the matrix.

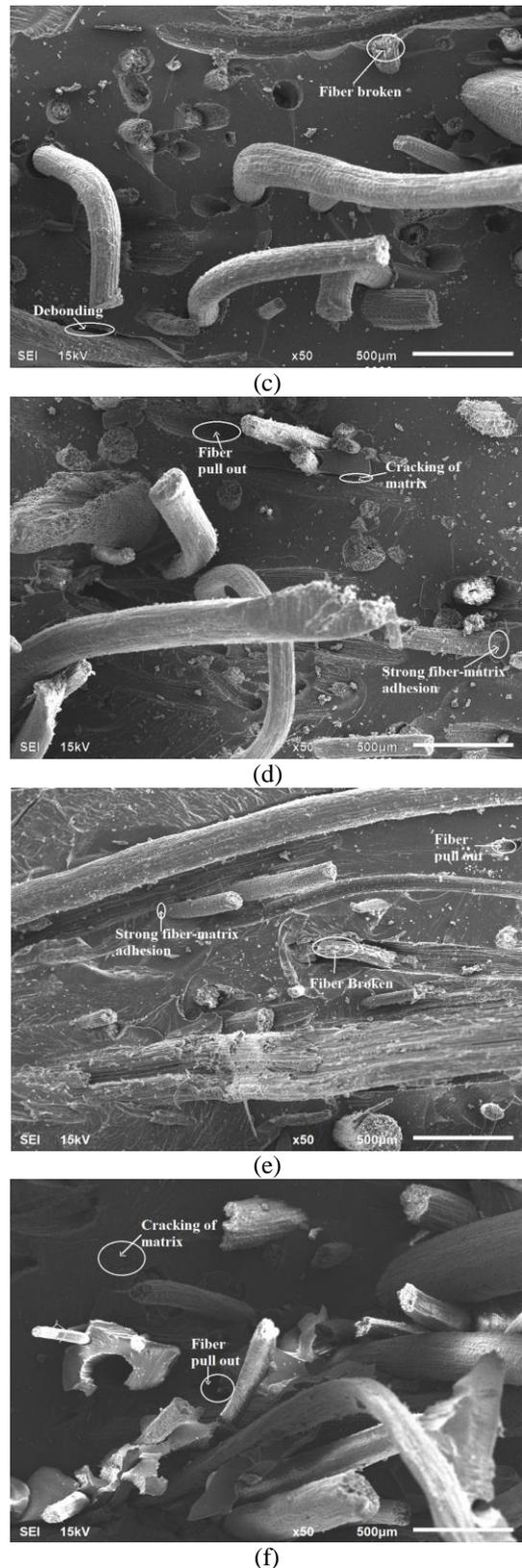
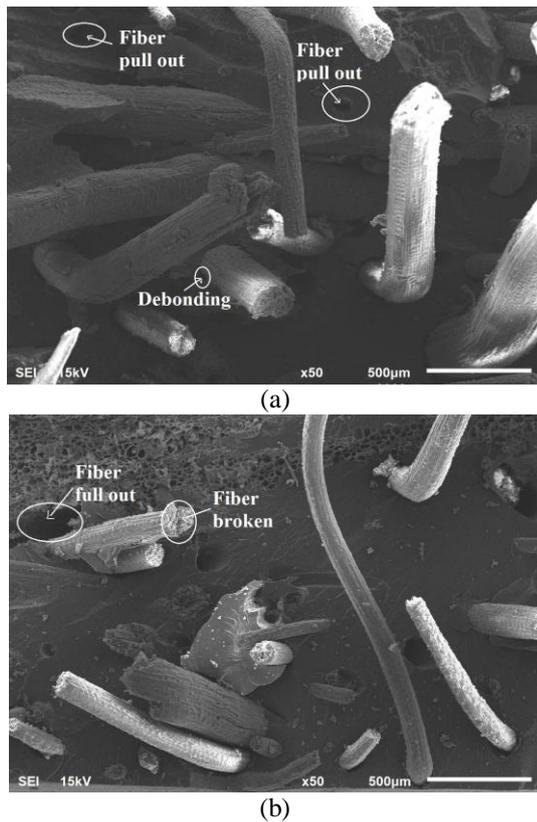


Fig.8 SEM images of tensile fracture of composite with: (a) untreated fiber (UT), (b) M10, (c) M20, (d) 2N, (e) NM10, and (f) NM20 treatments

IV. CONCLUSIONS

Alkali and microwave treatment were used to modify the surface of coir fiber as reinforcement of polyester composite. These treatments influenced water absorption and mechanical properties of coir fiber/polyester composite. The water absorption of alkali and combination of alkali and microwave treatments of composite decrease significantly in comparison to untreated fiber which shows improvement of wetting character of the composite. For the mechanical properties of the composite, all treatments of coir fiber tend to increase of tensile strength, tensile modulus, flexural strength, and impact strength due to good adhesion between fiber and matrix. However, for both M10 and NM20 treatments, the flexural strength of the composite declined. Then, the impact strength of 2N treatment of composite is lower than other treatments, whereas M10 treatment has a huge impact strength in comparison to the untreated fiber composite. In addition, the improvement of tensile strength of composite after coir fiber treatment was supported by SEM characterization with appearing good fiber-matrix adhesion.

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