EFFECT OF ALKALI TREATMENT ON THE TENSILE STRENGTH OF LIDAH MERTUA FIBER/ POLYPROPYLENE RECYCLED BIOCOMPOSITE

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Abstract – The purpose of this study was to determine the effect of alkali fiber treatment on the tensile strength of composites. The material in this study was recycled polypropylene from plastic beverage glass and lidah mertua fiber with a fiber length of 180 mm, fiber treatment using 5% NaOH and without treatment. Composite specimens were prepared using the hot press method at 170^{o}C for 120 minutes. Tensile testing with the dimensions of the test specimen refers to ASTM D-638. The results of the test carried out the maximum tensile strength value of 71,606 MPa in fiber with 5% alkali treatment. The tensile strength of composites with alkali treatment increased 223% compared to the tensile strength without alkali

Keywords: recycled polypropylene, fiber treatment, lidah mertua fiber, tensile strength

I. INTRODUCTION

Waste production per day in Denpasar City increased from 3,507.67 m^3 in 2014 to 3,719 m^3 in 2017, an increase of 6%. Inorganic waste production from 602.99 m^3 in 2015 to 982.97 m^3 in 2017, increased by 63%. In the national scope, the percentage of households that recycle waste is 1.2% and that burns waste is 66.8%. Data for 2017-2018 in the city of Denpasar produced plastic waste by 13.6%, and the production of plastic glass waste by 0.93%. Plastic waste made from thermosetting polymers harms the environment because plastic waste cannot be degraded, causing CO2 emissions and sometimes toxic gases when the material is burned while plastic waste made from thermoplastic polymer materials, especially polypropylene types such as drinking glasses can be recycled and can be recycled reused [1]. To reduce the problem of plastic waste, it is necessary to apply the principle of 3R (Reduce, Reuse, Recycle), reduce which is the activity of reducing plastic products, reuse that is reusing plastic waste, and recycle is the activity of recycling plastic waste. One of the efforts to recycle plastic waste is to use it as a composite filler material. Several studies have been carried out by researchers about the use of recycled plastic waste as a composite matrix combined with reinforcement of several types of natural fibers. The advantages of natural fibers include easily extracted, lightweight, renewable natural resources, biodegradable in nature [2]. Several studies on recycled plastic waste reinforced plastic composites have been carried out, one of them is recycled polypropylene composite reinforced with reeds [3], palm fronds [4], kenaf [5,6], sisal [7-9], palm fibers [10], wood [11], coir [12-13], hemp [14]. Indonesia with a tropical climate, there are various types of plants with fiber that can be utilized, one of which is the lidah mertua (*Sansevieria trifasciata*). Lidah mertua commonly known as "snake plant" or "mother-in-law" is a species in the family Asparagaceae. Lidah mertua grows well all over the world and has many Sansevieria species [15]. Lidah mertua is a type of ornamental plant that is quite popular as an ornamental part of the house because this plant can grow in conditions with little water and lots of suns. Lidah mertua entered Indonesia around the 1980s with laurentii and trifasciata types. The fiber content in these plants is relatively strong, does not cause health problems when processed, is easy to obtain and is a renewable material. The availability of abundant plants with fiber content that can be used as a reinforcing material in polypropylene plastic waste recycling composites.

II. METHOD

2.1. MATERIAL

Lidah mertua leaves were collected in Tumbakbayuh village, Mengwi sub-district, Badung District, Bali Province, Indonesia. The leaves were taken from the middle leaves with relatively the same length

2.2. FIBER EXTRACTION PROCESS

Lidah mertua leaves are collected and selected with the same relative length, as shown in Figure 1. The leaf midrib is mixed with a pipe before the water retting process is done, soaking in water for 7 days. After the water retting process the fibers are separated manually, then washed with running water until clean, as in Figure 2. The fibers are dried at ambient conditions for two days to reduce their water content, then stored in a waterproof plastic container.

Fig. 1. *Lidah mertua* leaves

Fig. 2. Water retting process

Recycled polypropylene used is used in certain brands of mineral water drinks. Plastic cups are cut into small pieces, cleaned with running water, then dried with air to remove the water that sticks, shown in figure 3

Fig. 3. Recycled polypropylene

2.3. ALKALI TREATMENT

Fibers pretreatment of the fiber using NaOH solution. The fiber is soaked in a NaOH solution with a concentration of 5% for 2 hours. The next process the fiber is rinsed in running water until clean then the pH of the immersion water is measured to normal pH, then dried for 5 days, as shown in Figure 4.

Fig. 4. Alkali treatment process

2.4. FIBER DENSITY

The density of fibers and polypropylene is measured using a pycnometer, as in figure 5 below

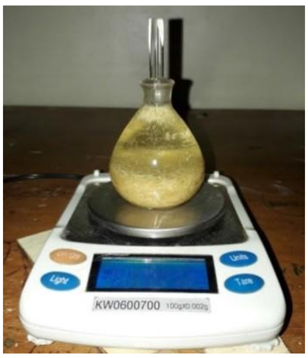

Fig. 5. Alkali treatment process

The formula to determines density:

ρ = ("#$ "&) / (")*+&,$("-*+#, x ρ_f

ρ = fiber density
ρ_f = fluid density
m_1 = pycnometer mass
m_2 = pycnometer mass + fiber
m_3 = pycnometer mass + liquid
m_4 = pycnometer mass + liquid + fiber

2.5. COMPOSITE MANUFACTURING

The composite manufacturing process by the hot press method, see in figure 6. *Lidah mertua* fiber with a length of 180 mm was used in this study at 35% fiber volume fraction. Pieces of plastic are sown first, then the fibers are arranged on top of the pieces of plastic in a uniform direction. Polypropylene pieces are placed on top. The mold is closed and given the pressure of 3 tons, the temperature is raised to 170°C and held for 2 hours. The mold is cooled using a fan airflow until it is cold, then the mold is opened.

Fig 6. Hotpress machine

The results of composite printing can be seen in Figure 7, the dark color is the composite whose fiber gets 5% NaOH treatment, while the light-colored fibers are without treatment.

Fig. 7. Composite mold

The composite is then cut with a cutting tool to make the test specimen, as in figure 8, below.

Fig 8. Cutting to make tensile test specimens

2.6. TENSILE TEST

The size of the tensile test specimen used with dimensions of length 165 mm, width 12.7 mm, thickness 3 mm by ASTM D-638.

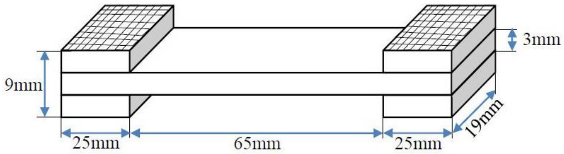

Fig. 9. Dimensions of tensile test specimens

In this study, two types of tests were carried out, composite specimens without alkali treatment, and composites whose fibers were treated with 5% NaOH. Composite tensile testing using the Tensilon RTG 1310 test machine was carried out at the Physics Lab of the University of Mataram, NTB.

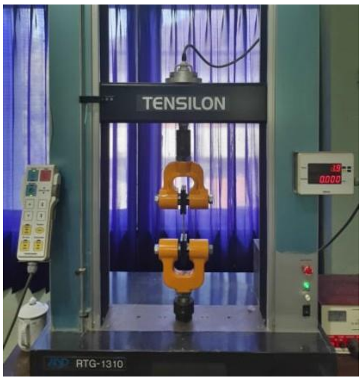

Fig.10. Tensile test machine

III. RESULT AND DISCUSSION

The results of the measurement of the density of Sansevieria trifasciata fibers without treatment and with 5% NaOH treatment, as well as, the density of recycled polypropylene with 6 repetitions can be seen in Table 1

Table 1. Fibers and polypropylene density

Experiment	Density (gr/cm^3)		
	Polypropylene	Fiber without alkali	Fiber with 5% NaOH
1	0,857	1,356	1,456
2	0,831	1,365	1,468
3	0,884	1,408	1,476
4	0,895	1,419	1,458
5	0,897	1,375	1,466
6	0,895	1,398	1,466
Average	**0,876**	**1,386**	**1,465**

Sansevieria trifasciata fiber used in this study is a fiber with a straight orientation with a fiber length of 180 mm. While the fiber volume fraction used is 35%. Tensile test specimens are tested in the Lab. The Physics University of Mataram uses tensilon RTG 1310 mechanical test equipment. The test results are calculated using the following formula.

$$\sigma = \frac{-}{/_{0}}$$

σ = Tensile strength (Mpa)
P = Force (N)
A = Surface area of fiber cross section (mm^2)

Tensile stress data can be seen in Figure 11 below

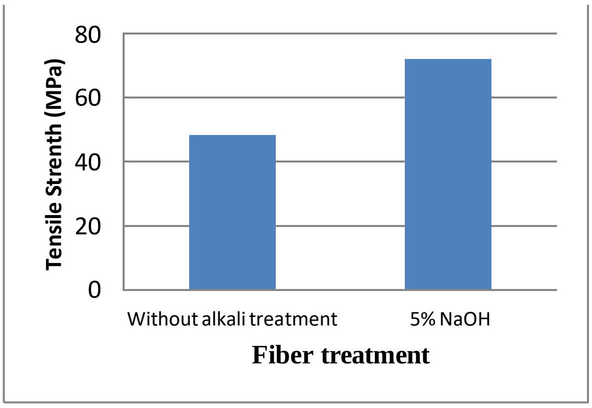

Fig. 11. Effect of fiber treatment on tensile stress

The highest tensile strength value is found in straight fiber with treatment that is equal to 71,606 MPa for straight fiber without treatment has a tensile strength of 48,052 MPa. An increase of 223% compared to the tensile strength without treatment. This can be caused by fibers with cleaner and rougher treatments because the lignin, wax, and impurities have been reduced so that it can increase the bond between the matrix and the fiber, good bonding of the matrix and fiber can increase tensile strength because the load received by the composite is fully forwarded by the fiber without the slip [16]. This is supported by the SEM test results in Figures 12 and 13 below.

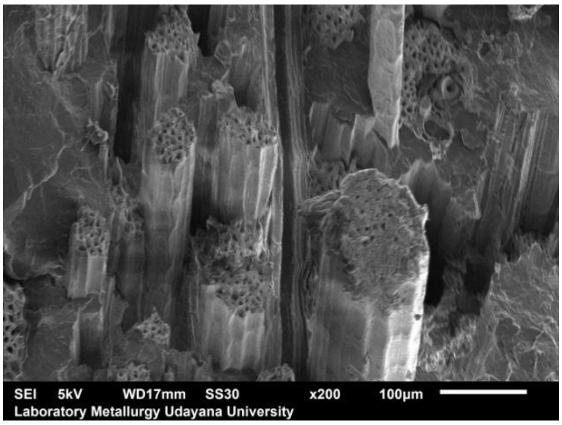

Fig. 12. SEM results of composites with 5% NaOH fiber treatment

SEM test results for straight fiber composites with the treatment showed more even fiber fractures with the matrix. This indicates a good bond between the fiber and the matrix where the load received by the composite is held simultaneously between the matrix and the fiber without any slip so that the composite failure due to the strength limit of the fiber is not due to the slip between the fiber and the matrix.

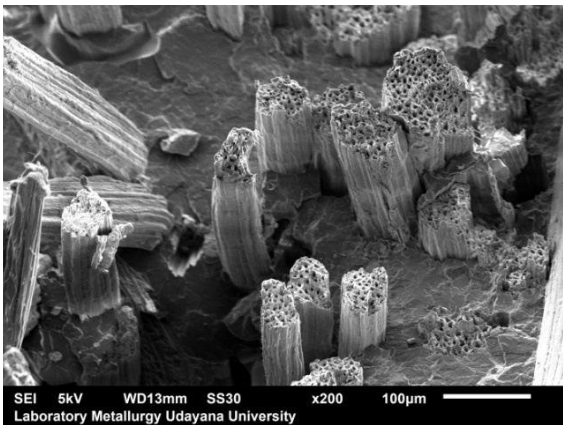

Fig. 13. SEM results of composites without alkali

SEM test results for straight fiber composites without NaOH treatment fiber fracture is dominated by pull out rather than flat fiber fracture with the matrix it shows the bond between the fiber and the matrix is not good so that the load is not received simultaneously on the fiber and the matrix due to slip so that tensile strength which is obtained is lower than the fiber with the treatment.

The results of the tensile strength of the composite with 5% NaOH treatment amounted to 71,606 MPa and the tensile strength without treatment amounted to 48,052 MPa. A significant increase of 223%. This can happen because in a straight fiber variation all fibers contained in the composite specimen receive a load that is passed on to the fiber with minimal slip.

IV. CONCLUSION

From the result and discussion above, it can be concluded that the lidah mertua fiber has a lighter density than glass fiber, so it can be used for light and environmentally friendly material applications. The treatment of *lidah mertua* fiber with 5% NaOH alkaline solution for 2 hours was able to increase the tensile strength by 223% compared to untreated fibers. This happens because in straight fibers all fibers contained in the composite specimen receive a load which is passed on to the fiber with minimal slip

ACKNOWLEDGMENT

Special thanks to Prof. Ngakan Putu Gede Suardana who guided this research.

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