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Effect of Fibreglass Reinforcement on Compressive Strength of Teak (*Tectona grandis* L.f.) Leaves Waste Composite

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Abstract. We have successfully fabricated a leaves waste/PVAc composite reinforced by fibreglassusing simple mixing and hot-press methods. This work was done by varying the composition of PVAc/leaves composite/fibreglass to obtain the effect of fibreglass addition in improving the composite compressive strength. From the compression strength test, we received the increasing of fibreglass fraction tends to improve the compressive strength, where for the 4.8% (w/w) of fibreglass the compressive strength of composite produced reached up to 33.9 MPa, or increased up to 51% compared to that of without fibreglass. It showed that fibreglass can increase significantly mechanical strength of the composite.

1. Introduction

Indonesia is a tropical country that has a wide variety of plant species. In each area, the trees grow so rapidly it also impacts the high trash. The issue of garbage being debated by themselves in the midst of society, because the public has not had an innovative way to process waste. If these to be allowed to continue, it will become a serious problem. On the other hand, the problem of deforestation to be a device manufactured furniture from year to year continues to increase. It certainly would reduce Indonesia's forest area.

One of the innovations that can be developed to overcome this problem is an engineering material. The design leaves waste material into other wood boards with a composite technique that is light, robust and durable. Design material derived from leaves waste can reduce the accumulation of trash. It also can increase the value of leaves waste that has not been utilised properly while such engineering minimises the number of timber production is so high. Masturi et al [1] conducted research manufacture using polymer composite leaves waste Polyvinyl acetate (PVAc) as a binder and silica as a reinforcing (filler).

In this work we usedteak leaves waste as composite materials, Polyvinyl acetate (PVAc) as polymer and fibreglass as reinforcement (Filler). Availability of a considerable amount in nature makes teak leaves selected as composite materials. PVAc was chosen because it has a strong adhesive so used as a raw material in the production of glue, cloth, paper, and wood. PVAc used because it has properties smelled, non-flammable, and faster condense. Masturi et al [2] states that the PVAc is also used to improve the strength of a composite.Sriyanti and Merlina has also used the PVAc as binder of nanocomposite material [3].

Fibreglass is chosen as filler to make stronger composites. Fibreglass can be used to reinforce composite because it has mechanical properties and can store energy very well [4]. Additionally, fibreglass is also suitable for use as a filler because it has excellent thermal conductivity [5]. Fibreglass also adapted to the pressure at high temperature or low temperature, have good elastic energy for the various stress [6].

2. Methods

In this research, leaves waste used is teak leaves (*Tectona grandis*) from leaves waste in Semarang, PVAc and fibreglass. The leaves residue was dried then smoothed using a blender machine. Teak leaf powder sieved to produce a powder in the same size. An FT-IR characterization was used to investigate the content of cellulose in teak leaves powder.

In the other hand, the fibreglass which still forms sheet cut into small pieces with a size 3-5mm while PVAc was solved with water and stirred using magnetic stirrer until homogenously for 15 minutes so easily mixed with a powder of leaves waste. The water was chosen because PVAc is a hydrophilic polymer. The PVAc solution mixed with teak leaves powder with a certain ratio as in Table 1. The mixture is stirred until uniform and then continued to press process. The pressed process has done by putting the dough into a cylindrical mould and pressed at 3 tonnes for 15 minutes. The sample pressed removed from the mould and then dried for 24 hours at room temperature. The work was continued with mixing fibreglass into the mixture of teak leaves powder and PVAC solution to obtain the effect of fibreglass on compressive strength of the composite.

Tabel 1. Composition of teak leaves powder,PVAc

Teak leaves powder (g)	PVAc(g)	Fibreglass (g)
16	4	0
16	4	0.2
16	4	0.4
16	4	0.6
16	4	0.8
16	4	1

Characterization of compressive strength performed to measure the mechanical strength of composite before and after mixed with fibreglass by cutting the sample in small cubic with a size of 2x2x2 cm. The compressive strength is expressed as

$$\sigma = \frac{P}{A}$$

where P is maximum load required to press the composite until destroyed and A is the area was depressed.

3. Result and Discussion

FTIR characterization results are shown in Figure 1. Measurement of IR spectrum only in the range of 4000-400 cm^{-1}. IR spectrum area divided into two areas of functional groups and regions fingerprint. The area of the functional group lies in the wave number 4000-1450 cm^{-1} while the fingerprint region lies in wave numbers below 1450cm^{-1}.

FTIR results of teak leaf powder compared with the results of FTIR on pure cellulose micro-granular cellulose powder from SIGMA) of high purity grade reagents [7]. For pure cellulose appears spectrum peak in the range of 3400 cm^{-1} to 3500 cm^{-1}, 2800-2900, 1160 and 1035 cm^{-1} to 1060. In the area, there is a fingerprint for the cellulose peak in the range of 1300-1400 cm^{-1} indicating the C-H bond [8].The FTIR spectrum of teakleaf powder showed a peak in the area of 780 cm^{-1}, 1075 cm^{-1}, 1233 cm^{-1}, 1437 cm^{-1}, 1631.29 cm^{-1}, 2929.05 cm^{-1}, and 3401.04 cm^{-1}. Overall peak existing on teak leaf powder is almost similar to the peak in real cellulose shift only slightly there.

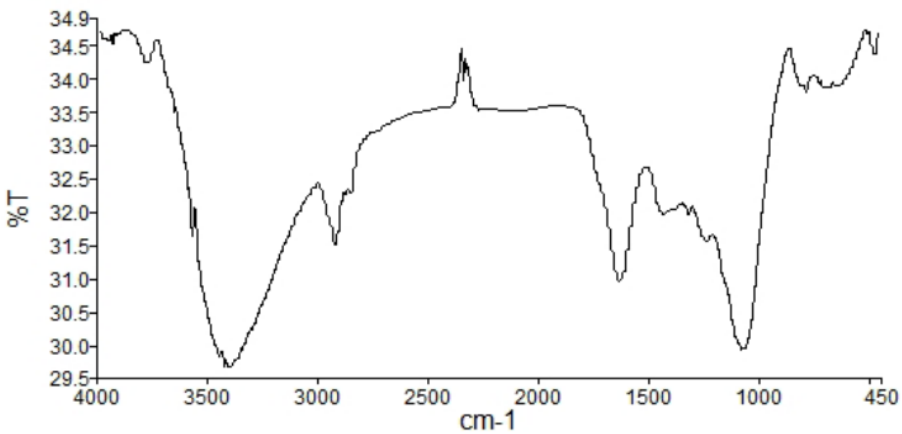

Figure 1.FTIR spectra of teak leaf powder

The peak of 2929.05 indicates the C-H bonds are strong and peak at 3401.04 indicates stretching group O-H bond. Meanwhile, the peak of 1631.29 cm^{-1} shows the absorption of water where hydrogen bonds formed between atoms of hydrogen and oxygen atoms of hydroxyl groups of the glucose monomers [8]. This bond indicates the presence of cellulose fibre formation. The peak of 780 cm^{-1} and 1437.7 cm^{-1} shows C-H bonding linking glucose units in the cellulose. Further, the peak of 1233.7 cm^{-1} indicates that there are groups C-O-C which is a structure of lignin. Absorption area happens to 1075.96 cm^{-1} shows the C-O bonds contained in the cellulose component [1,6,9].

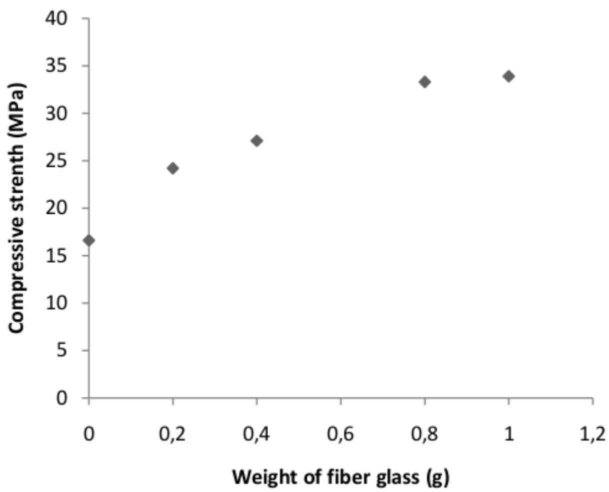

Figure 2. Compressive strength of composite

Figure 2 shows that the compressive strength of composite waste teak leaves before added the fibreglass has a compressive strength value of 16.6 MPa. The compressive strength is slight because only a sample composed of teak leaf powder and PVAc. PVAc is working to minimize the pores and form a strong bond with teak leaf powder [10]. Improving the compressive strength research, it continued with the addition of glass fibre. After added fibreglass, the compressive strength increased to 51% compared to the compressive strength without fibreglass.

The fibreglass can improve the compressive strength because these fibres play an important role as support the maximum load. The tension was applied to the composite initially accepted by the matrix then forwarded to the fibreglass so that the fibres will hold the amount up to maximum load. The increase in the compressive strength in composites with fibresglass do not occur continuously but stops at 33.9 MPa compressive strength. Composites in this condition are said to be in a state of saturation so that if the study continues, the compressive strength generated will be in the range of particular value or can go down. It is like the Masturi research's where a composite with silica powder was experiencing saturation. It occurs due to the addition of fibresglass is no longer effective in supporting the maximum load [10].

4. Conclusion

We have successfully made composite waste teak leaves with PVAc and the addition of fibresglass which had reached 33.9 MPa compressive strength or an increase of 51% compared to without the addition of fibreglass.

Acknowledgement

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