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# Effect of Calcium Carbonate on The Tensile and Density Properties of Kenaf/Polyester Hybrid Composite

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**Abstract**. Kenaf (*Hibiscus cannabinus L.*) was a plant belonging to the Malvaceae family. Kenaf was a natural fiber that has attracted researchers to explore its properties as reinforcement materials in composites. In addition, calcium carbonate (CC) particle can also improve the mechanical properties of composite. The aim of this study was to describe the fabrication of calcium carbonate particle reinforced kenaf/polyester hybrid composite. The hybrid composites were prepared using hand lay-up process with different particle loading (2.5%, 5%, 7.5%, 10% and 20% by weight). The hybrid composites were tested for tensile strenght using ASTM D368 standard. The highest tensile strength were showed for 5% wt calcium carbonate reinforced kenaf/polyester hybrid composite in this investigation. It was also observed that the density for hybrid composite decreased as the particle content increased.

## 1. Introduction

In recent years, hybrid composites have been developed by using more than one type, shape, or size of reinforcement. These composites have been developed to provide synergistic properties of the chosen fillers and matrix. They offer a range of properties that cannot be obtained with a single type of reinforcement [1]. Unsaturated Polyester is the most widely used resin, from the most basic and simple process (Hand Lay Up) until the process with machines and complex molds [2]. Natural fibers are now emerging as viable alternatives to glass fibers either alone or combined in composite materials for various applications in automotive parts, building structures and rigid packaging materials. The advantages of natural fibers over synthetic or man-made fibers such as glass are low cost, low density, competitive specific mechanical properties, carbon dioxide sequestration, sustainability, recyclability, and biodegradability [3].

Kenaf is a short day annual herbaceous plant that belongs to the Malvaceae, a family notable for both its economic and horticultural importance. The genus of Hibiscus is widespread, including some 400 species [4]. Kenaf fibres receive much attention owing to its prospective probability as polymer reinforcements in the natural fibre composite industry. Researchers claimed that mechanical strength and thermal properties of kenaf composite are superior to other type of natural fibre polymer composites, thus regarded as a suitable applicant for high-performance natural fibre polymer composites [5]

The purpose of adding mineral fillers to polymers was primarily one of cost reduction. In recent years, however, the fillers are more often used to fulfil a functional role, such as increasing the stiffness or improve the dimension stability of the polymer [6]. Calcium carbonate particle is a kind of new high-grade functionality filler with low cost, which is widely used in rubber, plastics, paint, and other industrial applications. It is a fact that the shape, size, and content of calcium carbonate can affect the overall properties of composites. Regarding size, the inorganic fillers have much smaller than the wood fibers, therefore they could be easily filled into polymeric matrix between wood fibers [7].

In this study, hybrid composites were fabricated by maintaining an unsaturated polyester (UP) loading of 80% by weight in all the composites. The addition of $CaCO_3$ (CC) into kenaf/polyester composite was evaluated. The aim is to reveal the potential of CC to be utilized as reinforcing filler for improving the mechanical properties of polymer composites.

## 2. Material and Methods

### *2.1. Materials*

Unsaturated polyester resin was used as matrix in the composite. YUKALAC BQTN 157-EX unsaturated polyester (UP) resin was purchased from Justus Kimia Raya Inc, Indonesia. The UP has density 1.1 g/cm$^3$ at 25 ºC and viscosity 4.5-5.0 poise at 25 ºC. Methyl ethyl ketone peroxide (MEKPO) was used as a hardener for the present research work. Kenaf fibers (shown in fig. 1a) were obtained from Balittas Malang, Indonesia. The kenaf fibers were immersed in 6% NaOH solution for three hours in a basin at room temperature.

The fibers were washed thoroughly with aquadest to remove the remaining NaOH and then dried at room temperature for 72 h followed by oven drying at 100ºC for 6 h. The kenaf fibers were then chopped into dimensions of 30 mm. The calcium carbonate particle (CC) was used, which was obtained from a by-product of bathware sawing and shaping from Apaiser factory (Industry of bathware production at Pasuruan, Indonesia). While, the CC particle used as composite reinfrocement has particle passed through sieve no 40 µm as shown in Fig. 1b).

**(a)** **(b)**

**Figure 1.** The image of (a) kenaf fiber, (b) calcium carbonate particle

### *2.2. Fabrication of Composites*

The CC/kenaf/polyester hybrid composite was fabricated with hand lay-up method. The first step, CC particle was added to polyester with variations in loading of 2.5 wt%, 5 wt%, 7.5 wt%, 10 wt% and 20 wt%. Magnetic stirring from these sample is carried out to make a homogeneous mixture of CC particle and polyester. The magnetic stirrer is set to rotate at 400 rpm for 5 minutes. After uniform dispersion, hardener (MEKPO) is mixed with an amount of 1% into a CC/polyester mixture.

After completing this step, one layer of polyester and CC mixture is poured evenly into the mold, and then the kenaf fiber is kept followed by pressing it uniformly to remove the void with the help of a spatula. The same procedure is repeated until all parts of the mold are filled. Then the mold is covered with a glass plate and the pressing process is carried out. After this step, the mold is left for 24 hours at room temperature for curing and then the sample is removed from the mold. The composition and designation of the hybrid composite for this study are given in Table 1.

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**Table 1.** Composition and designation of the hybrid formulations.

| No | Designation | Composition |
|---|---|---|
| 1 | UP | Unsaturated polyester resin specimen |
| 2 | S1 | Polyester (80 wt%) + kenaf fiber (20 wt%) |
| 3 | S2 | Polyester (80 wt%) + kenaf fiber (17.5 wt%) + $CaCO_3$ (2.5 wt%) |
| 4 | S3 | Polyester (80 wt%) + kenaf fiber (15 wt%) + $CaCO_3$ (5 wt%) |
| 5 | S4 | Polyester (80 wt%) + kenaf fiber (12.5 wt%) + $CaCO_3$ (7.5 wt%) |
| 6 | S5 | Polyester (80 wt%) + kenaf fiber (10 wt%) + $CaCO_3$ (10 wt%) |
| 7 | S6 | Polyester (80 wt%) + $CaCO_3$ (20 wt%) |

*2.3. Characterization*

*2.3.1. Tensile Test.* The speciment for the tensile test, was prepared and tested according to ASTM D368 (as shown in Fig. 2). The tensile strength of hybrid composites speciments, with different CC loading, were assessed using LY-1066A tensile tester, then their average result were recorded.

*2.3.2. Density Test.* The density of the composite can be determined experimentally by simple water-immersion technique [8]. The density of composite is calculated using Equation (1).

$$Density = \frac{Mass}{Volume} \quad (1)$$

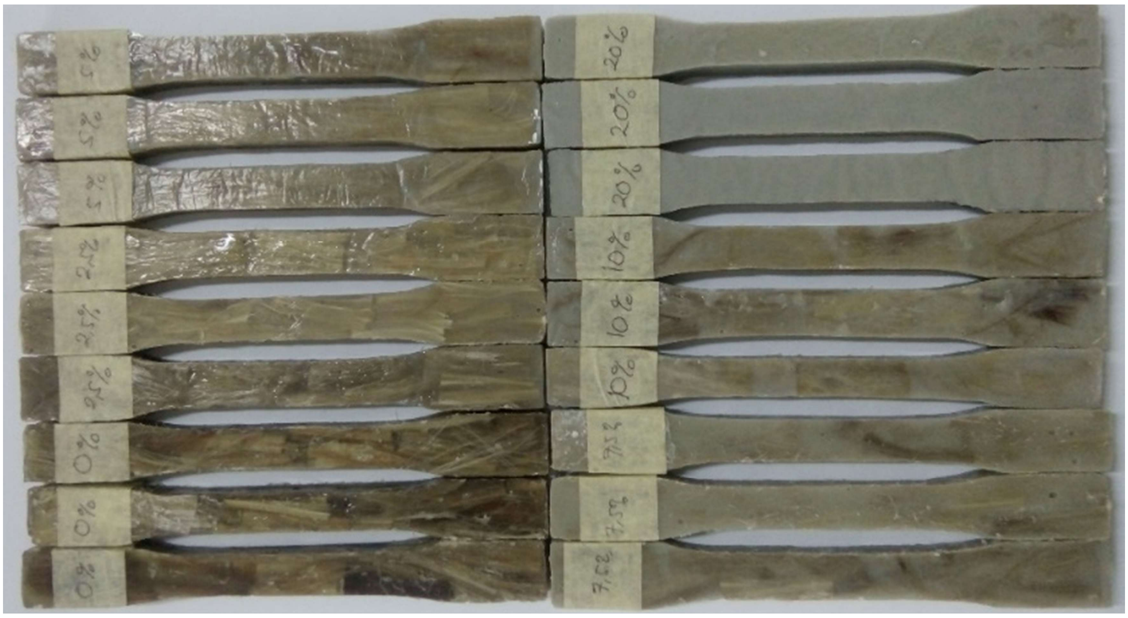

**Figure 2.** Speciment of tensile test

## 3. Result and Discussion

*3.1. Tensile Strength*

The average tensile properties of CC / kenaf / polyester hybrid composites are shown in Fig. 3. From the results obtained, it can generally be said that the loading of CC particles significantly affects the composite mechanical properties. It can also be observed that the composite of S2 showed maximum ultimate strength (43.38 MPa). Then, the addition of CC particles more than 5% of the tensile strength becomes decreased. The increase of filler content leads to formation of bigger agglomerates of filler particles. When the degree of agglomeration increases, the interactions between the filler and the matrix become weaker and, as a result, the values of the tensile strength decrease [9].

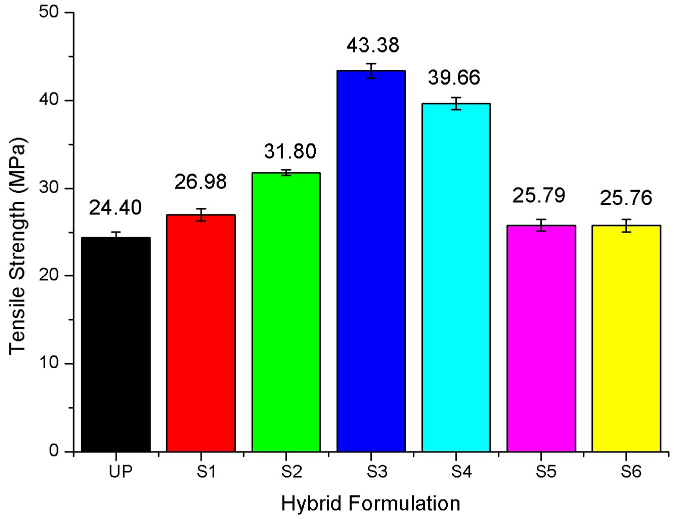


**Figure 3.** Tensile strength of CC/kenaf/polyester hybrid composite

*3.2. Density of Composite*

Based on the graph in Figure 4 shows a decrease in the density value along with the addition of CC particles. Sample of S6 becomes the lowest density sample. Decrease in density value is caused by the density of CC particles are smaller than the specific gravity of resin and kenaf fiber. So that the weight of the powder increases in composition, the composite specific gravity gets smaller.

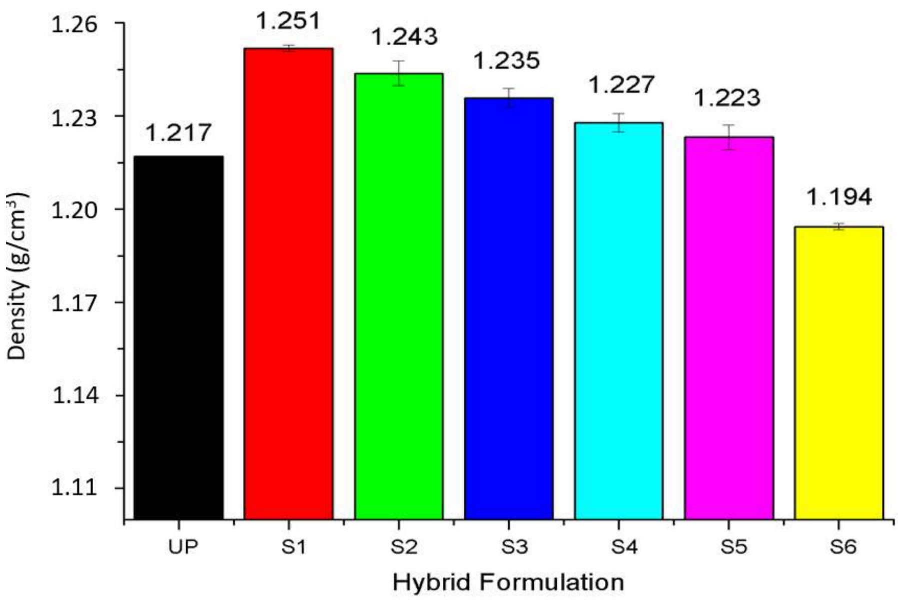


**Figure 4.** Density of CC/kenaf/polyester hybrid composite

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## 4. Conclusion

The CC-kenaf reinforced polyester hybrid composites were fabricated and characterised successfully. The addition of CC particles can generally affect the tensile and density properties of kenaf/polyester composite. The tensile strength of the CC-kenaf reinforced polyester hybrid composite for sample of S3 (5 wt% CC) showed a highest value (43.38 MPa). The density decrease with CC particle loading in hybrid composite. Minimum density was obtained in sample S6 (20 wt% CC); 1.194 g/cm$^3$.

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