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Preparation and Characterization of Mangrove *(Rizhopora Mucronata)* Charcoal-Epoxy Polymer Composite

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ABSTRACT

Composite materials have been widely developed and applied for various purposes. Polymer composites have excellent properties on mechanical strength and chemical resistance. This study aims to determine the strength of composite made of mangrove charcoal and epoxy since mangrove charcoal has a good character and is abundantly available. The mangrove charcoal was added into the epoxy-hardener matrix with a volume fraction of 10%, 20%, and 30%. The charcoal size was 40, 60, and 100 mesh. The highest tensile strength was found with a volume fraction of 10% with an average of 19.33 N/mm² at a size variation of 100 mesh mangrove charcoal. The highest elongation at break was found with a volume fraction of 10% with an average of 5.233% at 100 mesh mangrove charcoal size.

1. Introduction

As a tropical country, Indonesia has abundant natural resources such as coconut (Cocos nucifera) and mangrove wood (Rizhopora Mucronata). It is still very open for further study and development optimally utilized. Coconut shell charcoal and mangrove wood are usually further processed into briquettes and activated carbon until now used by the community for household, business, and industrial purposes [1].

Compared with charcoal materials, activated carbon is more practical, attractive, and clean. The formation and utilization of activated carbon from coconut shell charcoal have two advantages: the first can purify and absorb bacteria in water. The second advantage is that it can be one of the solutions to the environmental waste problem because the main source of raw materials is coconut shell waste [2]. Mangrove charcoal has been more commonly known as a fuel in fish roasting or other foods. The manufacture of mangrove charcoal is carried out through the carbonization of mangrove wood. Mangrove charcoal also shows good characteristics [3].

A composite is several multi-phase systems of combined properties, a combination of matrix or binder materials with reinforcement. This merger will produce composite materials with mechanical properties and characteristics that are different from the forming material so that a desired composite material can be planned [4]. Reducing weight and carbon emissions to minimize pollution is a significant challenge for the materials research community. This led many passenger car manufacturers to use polymer composite components [5].

The nature of composite materials is strongly influenced by the nature and distribution of the constituent elements and the interaction between them. Other important parameters that may affect the properties of composite materials are the shape, size, orientation, and distribution of the reinforcer (filler) and the various characteristics of the matrix. Mechanical properties are one of the

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properties of composite materials that are very important to study. For structural applications, mechanical properties are determined by the selection of materials. The role of mechanical properties in composites is to move the stress between the amplifiers [6].

In general, composite materials combine two or more three materials with several properties that are impossible for each component to have [7], producing material properties that have better properties than previous materials. So from now on, I want to develop mechanical properties of composites that typically use polyester matrices and epoxy matrices that are expected to exceed the strength and properties of polyester; the identification carried out shows that chemical stability and hardness increase as a result of cross-link tissues. Mixing resin with hardener produces a cure condition; the liquid becomes hard [8].

Epoxy has superior mechanical properties and is used very effectively as an adhesive and a laminating resin for most engineering applications. It offers excellent moisture barrier qualities when used in polymer composites. It binds hugely well to fibers for making fiber-reinforced polymer composites. The polymerization reaction to transform the liquid resin into the solid is induced by adding small amounts of a reactive curing agent before incorporating fibers into the liquid mix. One such curing agent is a hardener [9].

Epoxy is a thermoset polymer formed from the compound epichlorohydrin and bisphenol. Epoxy resins have been used in various fields, such as paints, electricity, civil engineering, and bonds [10]. The advantages of epoxy have excellent properties in mechanical strength, chemical resistance, electrical insulation, etc. In addition, epoxy has the disadvantage of its permanent nature; it is difficult to disassemble and easy to become slippery. To enhance certain functions, epoxy can be filled with inexpensive fillers but produce good mechanical strengthening and thermal conductivity [11].

Composites made of epoxy and some natural fibers and fillers have been widely studied. This research aims to study the mechanical properties of mangrove charcoal-epoxy composite, i.e., tensile strength and elongation at break. This research will contribute to the discovery of alternative composite materials.

2. Research Methodology

2.1. Materials

The materials used in this study were epoxy A resin and hardener B resin made by PT Justus Kimia Raya, mangrove charcoal, and silicon spray obtained from automotive stores.

2.2. Equipment

The tools used in this study include beaker cups, digital scales, specimen molds, glass stirrers, spoons, sandpaper, sieve shakers, and the test equipment used, namely *tensile testing machines* type RetroLine TC II for the Z020 TN Tabletop model.

2.3. Procedures

The mangrove charcoal was first prepared in three size variations, namely 40 mesh, 60 mesh, and 100 mesh, using a sieve shaker. The mangrove charcoal powder is presented in Figure 1. The mangrove charcoal bulk density was found at 0.4012 g/ml. In the next step, epoxy resin and hardener were mixed with a ratio of 1:1. Then, the mangrove charcoal was added to the epoxy resin-hardener mixture and stirred for 15 minutes until homogenous. The mixture was poured into a silicon-rubber specimen mold which had been previously sprayed with a silicon spray to prevent sticking. The size of the specimen followed the ASTM D638 type III test standard. The specimens were let to dry for 24 hours and taken from the mold. The volume fractions of mangrove charcoal added were 10, 20, and 30 %. The epoxy specimen and composite specimen are presented in Figure 2.

Fig. 1. Mangrove charcoal (40 mesh)

(a)

(b)

Fig. 2. Specimens: (a) pure epoxy (b) mangrove charcoal (10%; 40 mesh)-epoxy composite

Testing the mechanical properties of epoxy composites with mangrove charcoal stuffing materials includes tensile strength and break elongation. Tensile strength test using *Tensile Testing machine* test equipment retro line type TC II for Z020 Tn was carried out according to ASTM D638 test standard**.**

3. Results and Discussion

3.1. Tensile Strength

The mechanical properties study of epoxy composites with mangrove charcoal includes testing tensile strength and elongation at break. The effect of adding mangrove charcoal on the tensile strength of the composite is presented in Figure 1 and Figure 2. The tensile strength test is the static mechanical test by means of a sample being pulled by loading at both ends at a certain value of force [12].

Test results show the addition of mangrove charcoal to the polymer composite experienced a decrease in tensile strength value. The larger the composition of mangrove charcoal, the smaller the tensile strength value, and the smaller the composition of mangrove charcoal, the greater the tensile strength value. This is because the larger the volume fraction, the more air bubbles form in the composite, so the bond between the fibers of mangrove charcoal and resin does not occur properly. Composites with a volume fraction of 0% give the greatest tensile strength value. This is due to the homogeneous interaction of epoxy resins which causes the bonds that occur to be better because of the air bubbles that are trapped a little.

Tensile strength indicates the maximum acceptable tension of a composite, so based on Figure 3, the composite that can receive the greatest load is a composite with a volume fraction of mangrove charcoal of 10%. In comparison, the composite that can absorb a load is the smallest, namely a composite with a volume fraction of mangrove charcoal of 30%. The previous research reveals that adding a volume fraction will lower the maximum acceptable tension value of the composite. At a fraction of 1% of 37.357 N/mm^2. 3% of 30.917 N/mm^2, and 6% of 29.87 N/mm^2 [13]. Comparing the research, using mangrove charcoal as a composite filling material provides the same tensile strength gain as composites made from coconut shell charcoal filling. In contrast, using mangrove charcoal and coconut shell charcoal gives a smaller tensile strength value with increasing volume fractions.

The tensile strength value of a volume fraction of mangrove charcoal of 0% or 100% epoxy is 19.07 N/mm^2. Figure 3 reveals that the tensile strength value of each size variation has the highest value at a volume fraction of 10%, where the variation in the size of mangrove charcoal affects the tensile strength value. The larger the size of mangrove charcoal, the smaller the tensile strength value. This is because mangrove charcoal is large and not optimal when binding to epoxy. It can be seen in Figure 4 that the largest mangrove charcoal size (40 mesh) has the smallest tensile strength value and the smallest mangrove charcoal size (100 mesh) has the largest tensile strength value. The previous research shows that the tensile strength of composite depends on the size of material added; the smaller the diameter of the fibers will result in higher composting power [14]. The smaller size of charcoal results in a more homogenous composite and leads to higher tensile strength.

The tensile properties of mangrove charcoal-epoxy composites were found to be lower than those of glass fibers-epoxy composites [15] but equivalent to those of sisal (*Agave sisalana*) fibers-epoxy composites [16].

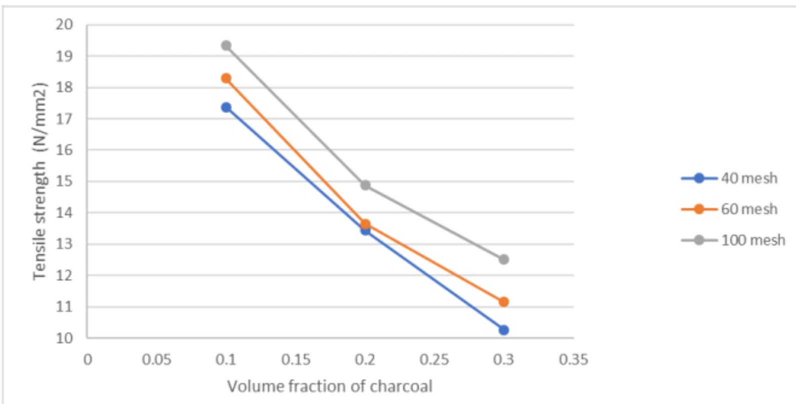

Fig. 3. Tensile strength testing chart

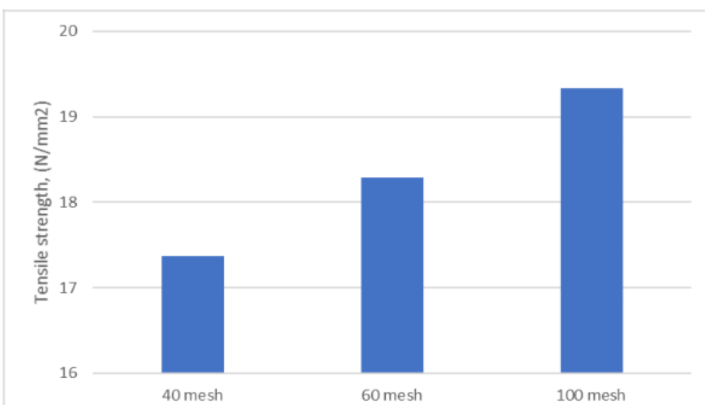

Fig. 4. Tensile strength at 10% of charcoal composition and different size of charcoal

3.2. Elongation Break

Elongation break is impacted by the filling material and softening the material. The elongation at the break value is directly proportional to the tension break [17]. Pure specimen or 100% epoxy has an elongation at a break of 5.547%. In comparison, the elongation at the composite break for various compositions is presented in Figure 5 and Figure 6.

Based on the percentage of elongation break, it can be seen that composites made from a mixture of epoxy and mangrove charcoal have the largest break elongation value found in the volume fraction of mangrove charcoal of 10% of each size variation. Where the greater the volume fraction of mangrove charcoal used, it turns out that it has a smaller elongation break value. The composite elongation at break value of the mangrove charcoal volume fraction of 10-30% is lower than elongation at break of 100% epoxy. This shows that adding mangrove charcoal leads to decreased elongation at the composite break. The higher the amount of mangrove charcoal added, the lower the elongation value at the break.

The effect of adding mangrove charcoal on the elongation at the break of the composite is presented in Figure 3 and Figure 4. Figure 3 shows that the largest elongation break value is found in composites with a variation in the size of mangrove charcoal of 100 mesh. The smallest elongation break value is found in the sit compound with a variation in the size of mangrove charcoal of 40 mesh. This happens because the smaller the size of mangrove charcoal will produce composites with a larger density of mangrove charcoal compared to the larger size of mangrove charcoal. The higher amount of mangrove charcoal contained in the composite, the smaller the elongation at break value. According to the research results [13], there is a decrease as the number of *filler weight fractions* increases. In the 0% fraction, elongation at break was obtained at 7.72%, the 1% fraction at 7.6%, the 3% fraction at 7.5% and the 6% fraction at 7.47%. The same result was also obtained by [16], who stated that tensile strain decreases with the increase in fiber volume fraction. The highest tensile strain occurs at the 15% fiber volume fraction, which is 1.018%, and the lowest in the 25% fiber volume fraction, which is 0.5%. The value of the elongation break is influenced by the material elasticity properties of the fibers. According to the previous study [18], the elongation value at break will be high if a material tested has elastic properties. Mangrove wood material belongs to the category of inelastic solids. Therefore, mangrove charcoal does not have a large break extending value and will tend to decrease if the volume fraction increases in the composite.

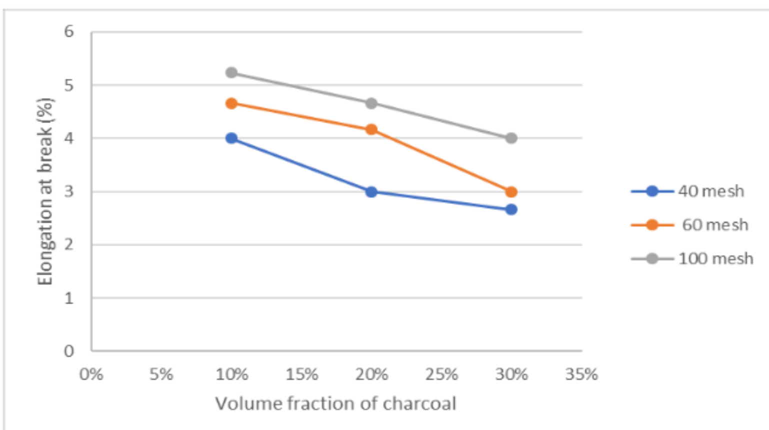

Fig. 5. Elongation at break for different volume fractions

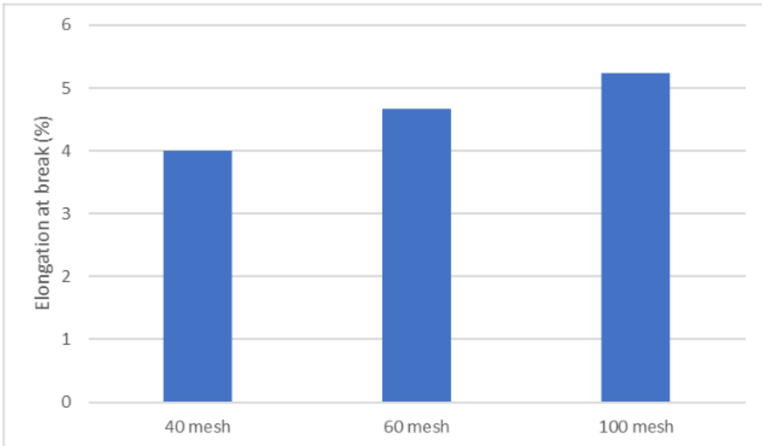

Fig. 6. Elongation at break at 10% of the charcoal composition and the different size of charcoal

4. Conclusion

Based on the result of the study, it was concluded that adding mangrove charcoal would affect the tensile strength and elongation at break. The addition of 10% mangrove charcoal slightly increases the tensile strength test, but adding the mangrove charcoal percentage will decrease the tensile strength. Adding mangrove charcoal to epoxy resin will reduce the elongation at break from 5.547% to about 2-3% with 30% mangrove charcoal. The mangrove-charcoal composites have a good mechanical property and potential for further development.

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