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Proceeding Paper

Effect of Volume Fraction of Epoxy Matrix Coconut Shell Composite on Tensile and Impact Loads †

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Abstract: This research aims to determine the effect of the volume fraction of coconut shell composite, with an epoxy matrix at 10% coconut shell water content, on the composite's tensile strength, impact, density, and fracture results with the macrostructure. The materials used to make this composite are coconut shell particles, with a diameter of 1mm at a water content of 10%, and epoxy matrix and hardener, in a ratio of 1:1. Variations in volume fraction are 10%, 20%, 30%, 40% and 50%. The composite was manufactured using a press mold. Composite testing was in accordance with ASTM standards for tensile testing, using ASTM D 638-02 and impact testing using ASTM D 256-00. Macro photo results that determine the type of fracture that occurred were taken of the fracture resulting from tensile and impact tests. The test results showed that the highest tensile strength was at a volume fraction of 40% of 21.59 MPa, and the lowest was at 10% of 7.15 MPa. The highest impact value was shown in a composite with a volume fraction of 50% of 0.074 J/mm^2, and the lowest had a volume fraction of 10% of 0.010 J/mm^2. The highest density was a composite with a volume fraction of 50% of 1.067 gr/cm^3, and the lowest had a volume fraction of 10% of 1.014 gr/cm^3. In observing the fracture after tensile and impact testing, it can be seen that the fracture was brittle, and the direction of crack propagation is perpendicular to the direction of the tensile stress that is acting to produce a relatively flat fracture surface.

Keywords: volume fraction; coconut shell; epoxy; press mold

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1. Introduction

In recent years, Indonesia has increased its coconut production, highlighting its growing importance in global agribusiness. This increase is due to agricultural technology and rising coconut product demand that has positioned Indonesia as a major producer and exporter of coconut products. Its large exports of coconut oil and other derivatives reflect its efforts to sustain and improve coconut production [1,2]. The varied use of all coconut plant parts is crucial to Indonesia's economy. Smallholder farmers cultivate most of Indonesia's coconut crops. Small-scale farms are vital to many Indonesian households, but face obstacles such as limited economies of scale, funding, and training, as well as dependence on traditional agricultural methods and basic crops like coconut seeds and copra. Diversification and value chain tactics are being used to boost coconut growers' income [3].

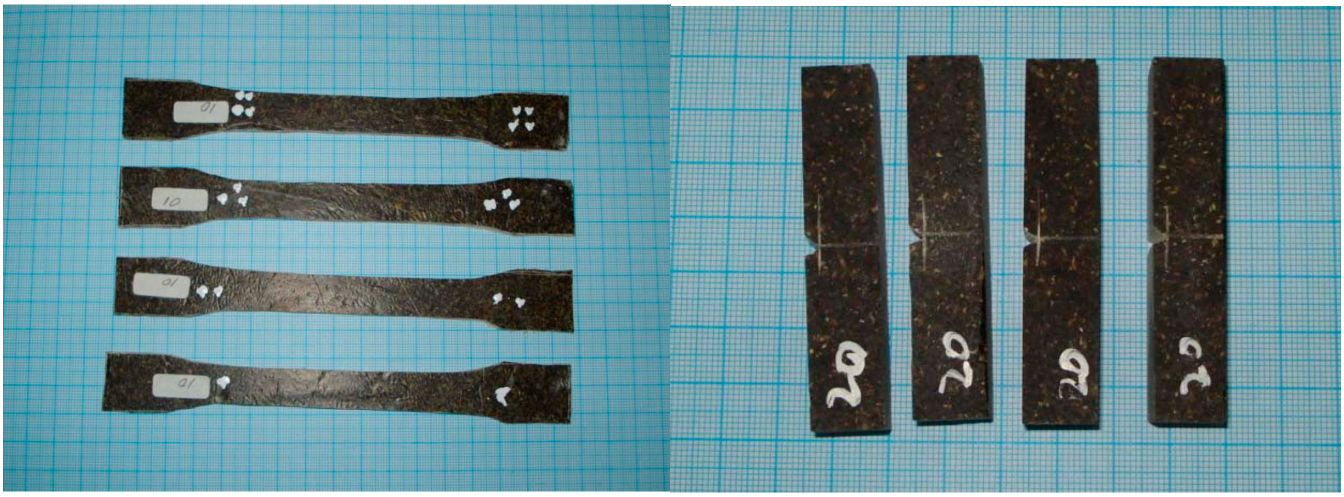
Coconut shells, once used as fuel, are now an important Indonesian industrial raw resource. Coconut shells may be used to make many value-added products, and charcoal and activated charcoal are often utilized for their adsorption properties [4,5]. Coconut shell composite is cheaper and ecological [6–8]. Coconut shell particles transmit the matrix's load, and considerably affect the composite's mechanical properties. Particle size, shape, orientation, and material affect composite mechanical characteristics. Alternative composites can be made with coconut shell particles and epoxy. Changing particle diameter and volume percentage should maximize coconut shell composite mechanical properties in a way that enables other composites [9,10]. Researchers have extensively examined coconut shell composite performance.

Livingston et al. [11] examined the tensile, flexural, and impact mechanical properties of vinyl ester composites by using treated and untreated coconut shell particles, and found that they improved material qualities. Two coconut shell particles, treated and untreated, increased mechanical properties by 35 wt%, with the treated condition having a higher property value. Both later lost value. Kumar et al. [7] discovered that property values increased in hybrid nano-metal matrix composited (HMMC) AA7075 reinforced with nano-microsized particulated Al_2O_3 and coconut shell ash (CSA). Ultrasonic-assisted stir-casting mixed Al_2O_3 and CSA, and mechanical, thermal, and corrosion data were examined. Tests included SEM, EDS, XRD, which examined porosity, tensile, damping, dislocation density, coefficient of thermal expansion, and polarization. It was found that strengthening the Al_2O_3-CSA mixture equally distributes nano- and micro-sized particles in the matrix, and that porosity and dislocation density affect damping, and it was also noted that Al_2O_3 and CSA lower HMMC's thermal expansion coefficient. As AA7075 matrix reinforcement weight percentage increases, so does corrosion resistance. Sujiono et al. [12] studied the synthesis and physical properties of graphene oxide/neodymium oxide (GO/Nd_2O_3) composite, and observed that adding coconut shell components to other materials increases mechanical properties and can be used as an environmentally friendly electrical component. Coconut shells help synthesis graphite with GO. GO was made using a modified Hummers process, and the Sonochemical process was employed to make a composite characterized by XRD, FT-IR, SEM-EDX, Raman, and UV-Vis Spectroscopy. XRD measurement showed that adding Nd_2O_3 nanoparticles to GO increases crystallinity. The FT-IR spectra test then yielded six functional group bonds and REOs (Nd_2O_3) at 678 cm. Raman spectroscopy revealed an ID/IG intensity ratio of ~0.85 and a sp2 graphite area size of ~22.6 nm, and SEM showed a three-dimensional carbon network in the composite. After the use of Urbach Energy, it was found that the GO/Nd_2O_3 composite might be used in electronic equipment using 0.050–0.063 eV semiconductor materials. Masyrukan et al. [13] heated and pressed an Al-Si alloy using coconut shell charcoal as part of a study examined hardness, density, and microstructure morphology. Heat treatment was found to, on average, increase hardness to 133 VHN. After heat treatment, the microstructure showed morphological alterations, including a drop in silicon concentration and an increase in alloy density.

Research of the use of coconut shells in combination with other materials is very promising, as it holds out the possibility of more environmentally friendly and economically priced alternatives. In this study, the researchers therefore used coconut shells in particle form as a composite reinforcing material and emphasized their volume fraction.

2. Research Method

Coconut shell particle composites were made with varying volume fractions of 10%, 20%, 30%, 40% and 50% at a particle diameter of 1 mm. Coconut shell particles with a water content of 10% were first coated using a mixture of epoxy resin and hardener, according to variations in volume fraction, and molded by using the press mold method with a 5–7 h drying time. The finished hardened coconut shell was cut into specimens according to standards in the Tensile test, and specifically the ASTM D638-02 type 1 standard [14]. In contrast, the ASTM D256-00 standard [15] was used for the impact test, as shown in Figure 1a,b. The dimensions of the specimen Tensile testing are shown in Figure 2.



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

Figure 1. (**a**). Tensile Test Speciment. (**b**). Impact Test Speciment.

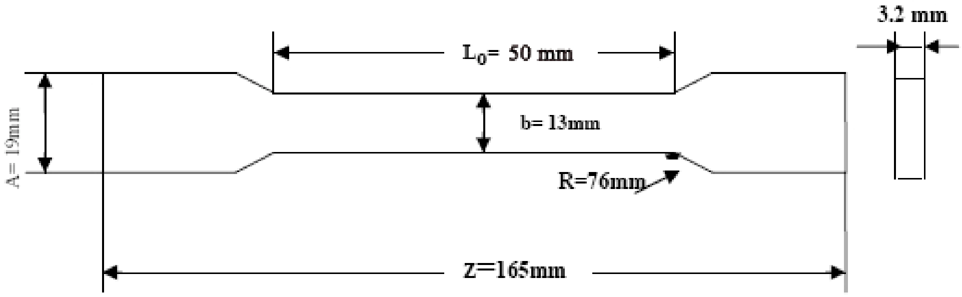


Figure 2. Tensile Test Speciment Geometry.

After all specimens were made, each variation of specimen type was tested for material by using the ASTM D638-02 Standard Tensile test, ASTM D256-00 standard Izod impact test, Composite Density, and macro photos from both Tensile and Impact tests.

3. Research and Discussion

3.1. Tensile Test Results

The particle composite is given tensile loads in different directions in tensile testing. Failure or fracture starts from the composite containing voids. The greater the load, the faster the fracture will occur. In most cases, when composites are subjected to tensile testing, the fracture is likely to occur in the composite where there are voids. Data from tensile test results shows that as the volume fraction increases, the tensile strength becomes greater. The highest tensile strength at a volume fraction of 40% was 21.59 MPa, and the lowest at a volume fraction of 10% was 7.15 MPa. The highest strain at a volume fraction of 40% was 8.1%, and the lowest at a volume fraction of 10% was 2.8%. Tensile test results are shown in Figure 3.

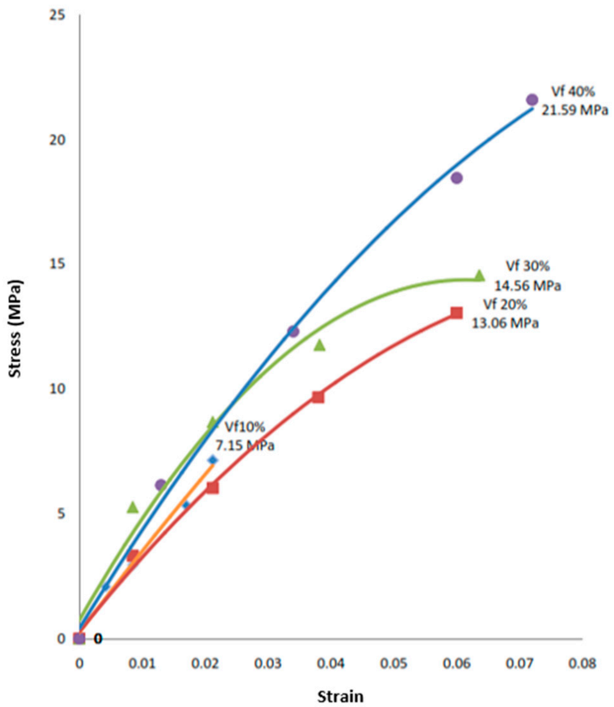


Figure 3. The Relationship between Stress and Strain at Varying Volume Fractions of 10%, 20%, 30%, 40%.

3.2. Impact Test Results

The impact test results show the difference between the average impact prices of the composites is caused by several things. Among other things, this is due to the uneven strength of the composite and the uneven distribution of particles, meaning the energy absorbed in the composite is different. Impact test result data show that the highest average absorption energy is at a Vf 50% volume fraction of 10.1 J/mm^2, and the lowest is at a 10% volume fraction of 1.4 J/mm^2. Meanwhile, the highest average impact strength value is at a Vf volume fraction of 50% of 0.074 J/mm^2, and the lowest is at a volume fraction of 10% of 0.010 J/mm^2. Impact test results are shown in Figures 4 and 5.

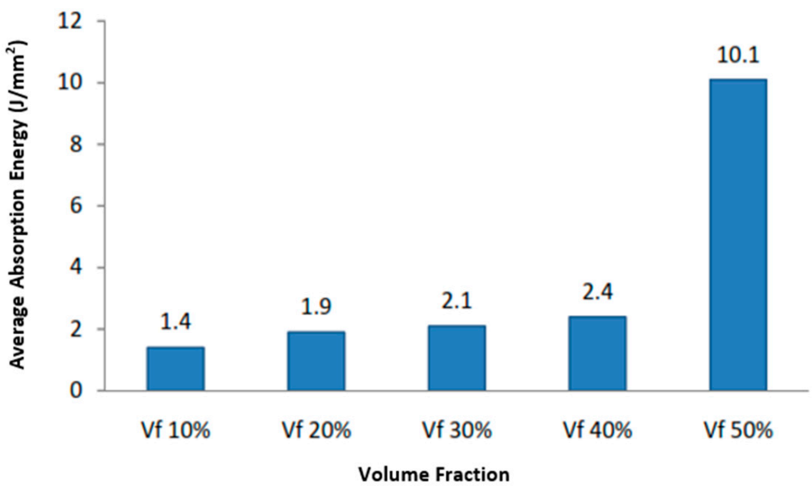


Figure 4. Histogram of the Average Absorption Energy of Coconut Shell Composite with Epoxy Matrix at a Particle Diameter of 1 mm.

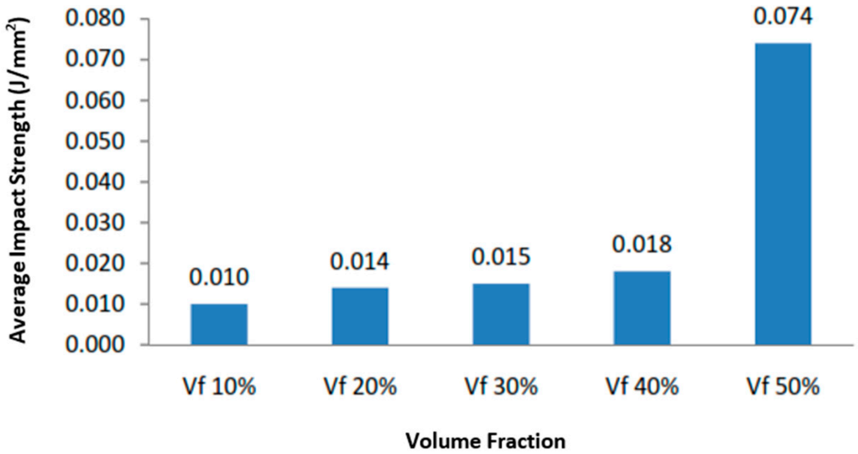


Figure 5. Histogram of Average Impact Strength Values for Coconut Shell Composite with Epoxy Matrix at a Particle Diameter of 1 mm.

3.3. Composite Density Test Results

In testing the density of coconut shell composites with an epoxy matrix on a particle diameter of 1 mm, we see that the higher the volume fraction, the greater the density of the composite. Such occurrence is caused by higher volume fractions, such as in a volume fraction of 30% (30% particles, 70% resin) or a volume fraction of 50% (50% particles, 50% resin). The more particles in the mixing rules, the heavier the composite (in grams). Density is mass divided by volume; the greater the mass, the greater the density in the same volume. The results of the composite density test are shown in Figure 6.

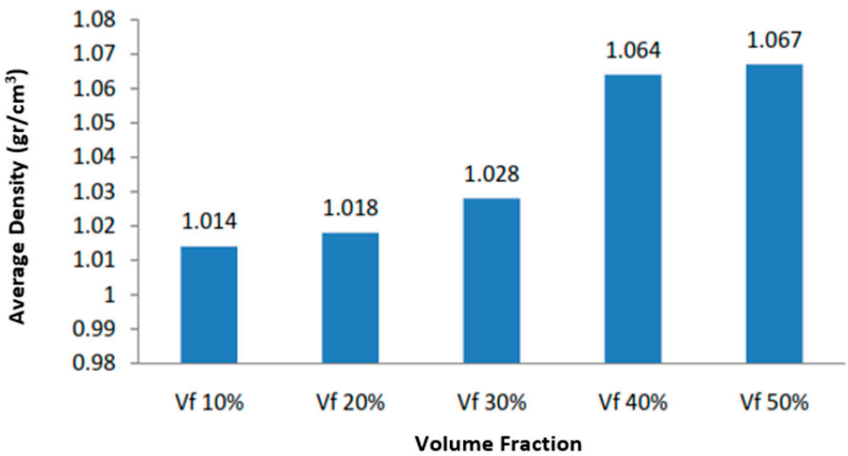


Figure 6. Histogram of Average Density of Coconut Shell Composite with Epoxy Matrix at a Particle Diameter of 1 mm.

3.4. Macrostructure Testing

In observing the macrostructure at Vf volume fractions of 10%, 20%, 30%, 40% and 50%, it can be concluded that the type of fracture that occurred was brittle, which strengthens the theory that brittle fracture occurs without significant deformation and experiences rapid crack propagation. The direction of crack propagation is perpendicular to the direction of the applied tensile stress. It produces a relatively flat fracture surface, as in the macro photo of the tensile and impact tests. The crack will therefore propagate very quick brittle fracture with small deformation. Such cracks are referred to as "unstable cracks", and crack propagation, once initiated, will continue spontaneously without additional applied stress. The results of the macrophoto of tensile test are shown in Figure 7 and Impact Test in Figure 8.

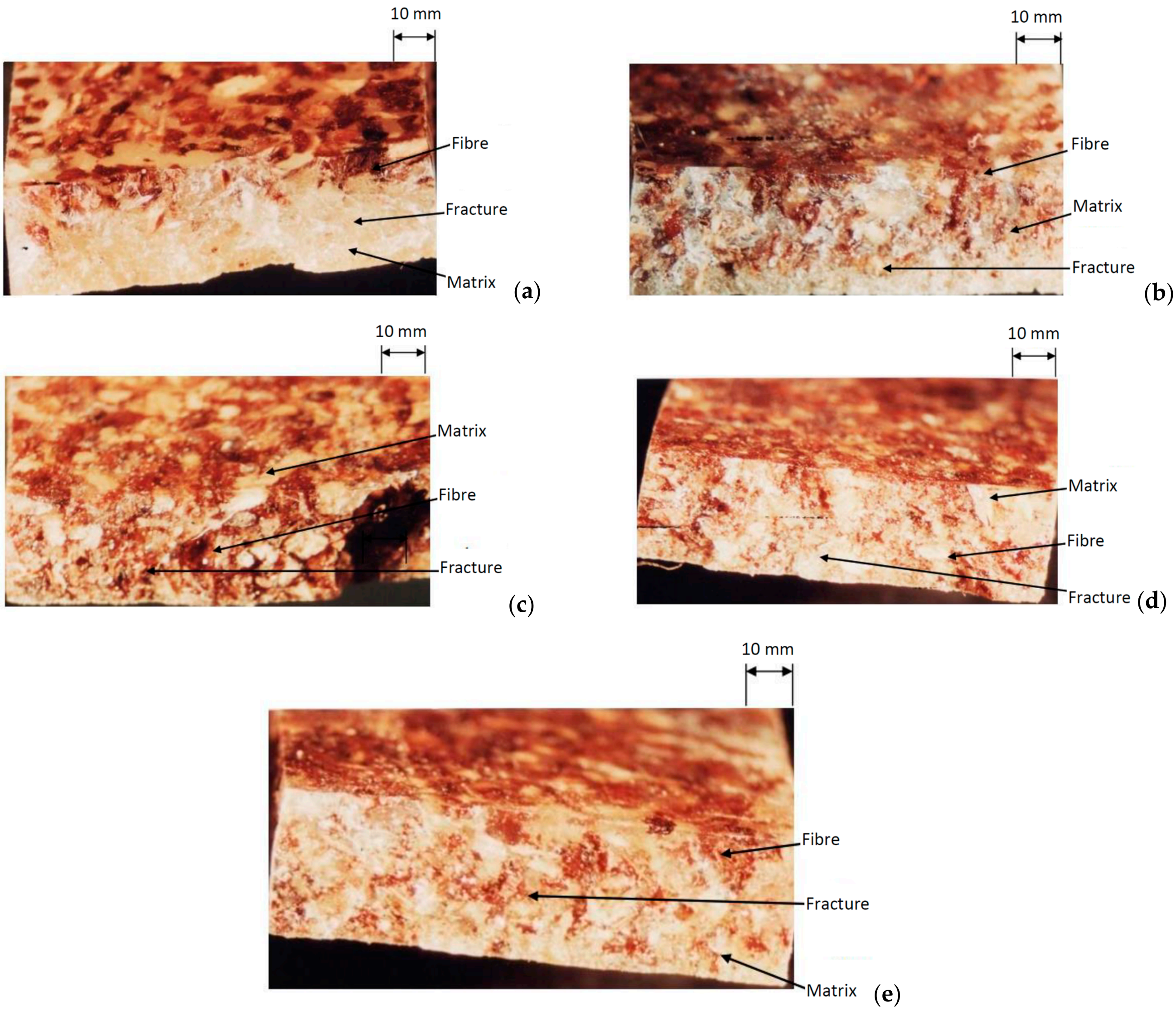


Figure 7. Cross section macro photo of tensile test specimen Vf = 10% (**a**), 20% (**b**), 30% (**c**), 40% (**d**) and Vf = 50% (**e**).

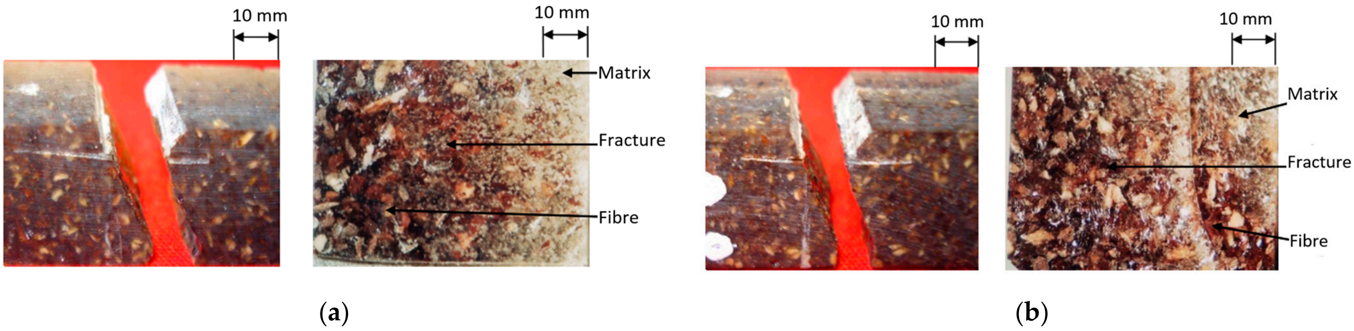


Figure 8. *Cont.*

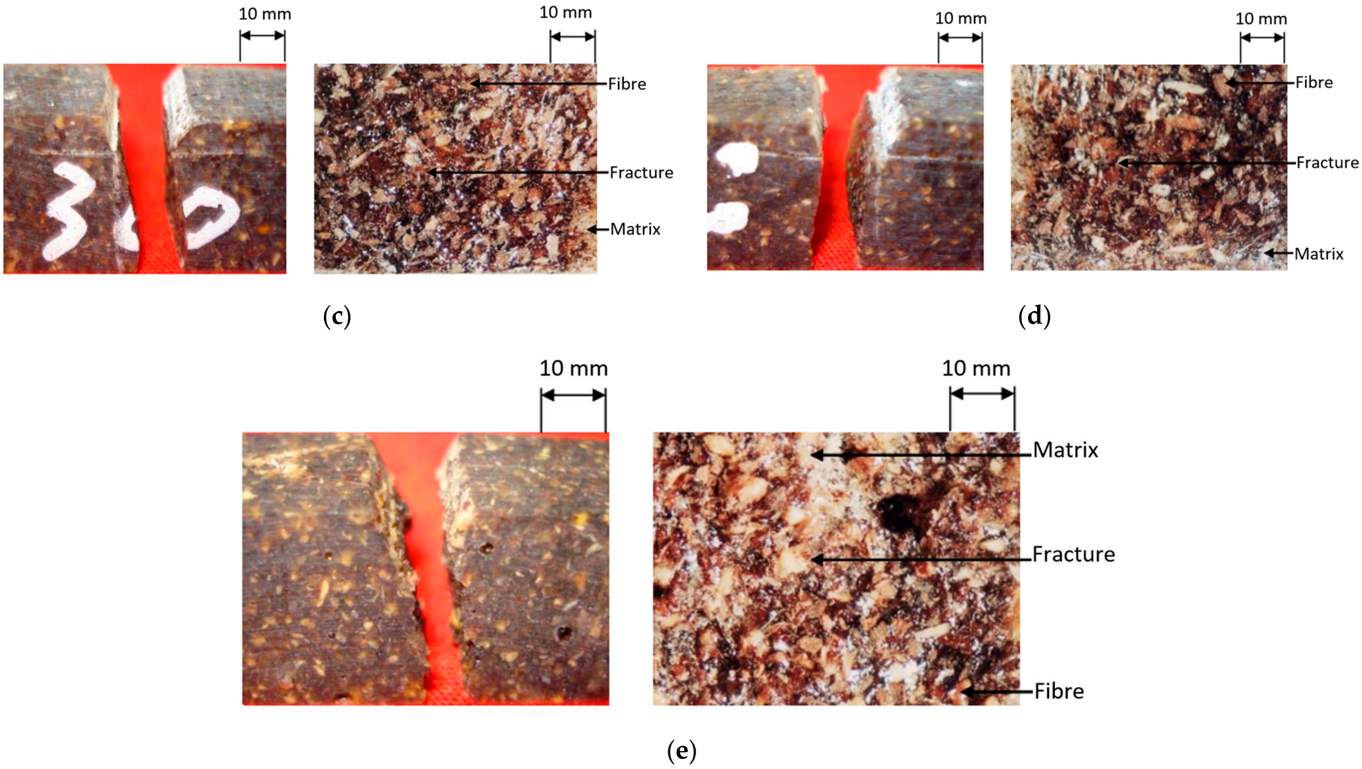


Figure 8. Cross section macro photo of impact test specimen Vf = 10% (**a**), 20% (**b**), 30% (**c**), 40% (**d**) and Vf = 50% (**e**).

4. Conclusions

The analysis, composite testing and discussion of the data lead us to draw the following conclusions:

1. On the basis of data from tensile testing results, it is known that as the volume fraction increases, the tensile strength becomes greater. The highest tensile strength at a volume fraction of 40% was 21.59 MPa, and the lowest at a volume fraction of 10% was 7.15 MPa. The highest strain at a volume fraction of 40% was 8.1%, and the lowest at a volume fraction of 10% was 2.8%.
2. On the basis of data from impact testing results, it is known that as the volume fraction increases, the impact price increases. The highest average impact value is for the composite with a volume fraction of 50%, amounting to 0.074 J/mm^2, and the lowest with a volume fraction of 10%, amounting to 0.010 J/mm^2.
3. The highest composite density at a volume fraction of 50% was 1.067 gr/cm^3, and the lowest was at a volume fraction of 10%, at 1.014 gr/cm^3.
4. In observing the fracture after tensile and impact testing, a brittle fracture can be noted, with the direction of crack propagation being perpendicular to the direction of the acting tensile stress, producing a relatively flat fracture surface.

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