Characteristics Mechanical Properties of Polyester Composite Reinforced Musa Acuminata Stem Fiber with Filler Carboxyl Terminated Butadiene Acrylonitryle

Sujita Sujita(✉), Anak Agung Alit Triadi, Made Wijana, and Pandri Pandiatmi

University of Mataram, Mataram 83125, Indonesia
msn@unram.ac.id

Abstract. This study investigates the impact toughness, tensile strength and morphology of the polyester matrix composite material reinforced with Musa acuminata stem fiber (MASF) and carboxyl terminated butadiene acrylonitryle (CTBN) filler. The fiber used was taken from the outer layer of the pseudo-stem banana species Musa acuminata, which came from Tanjung, North Lombok Regency, West Nusa Tenggara Province, Indonesia. The results showed that the addition of CTBN caused the MASF-reinforced polyester matrix to decrease its tensile strength, but increase its impact toughness. The reason is that CTBN is elastic so that it can increase the ductility, the impact toughness of the specimen increases. Based on the results of the SEM test, the bond morphology between polyester, CTBN, MASF is good.

Keywords: Musa Acuminata Stem · Carboxyl Terminated Butadiene Acrylonitrile · Tensile Strength · Impact Thoughness

1 Introduction

The limited non-renewable natural resources are one of the reasons, the development of materials is focused on the field of composite materials. Because composite materials have several advantages, high strength to weight ratio, stiffness, good corrosion resistance [1]. The use and utilization of composites today are continuously being developed in the manufacturing industry. One of them is the development of composite materials by using reinforcement in the form of natural fibers, artificial or fibers and fillers, designed according to needs.

Matrix polyester has various advantages as an adhesive compared to other polymers. Among them are high surface activity, does not shrink, can be flexible to change its properties by choosing the right resin hardener. Epoxy adhesive strength does not change in a long time, resistant to oil, grease, heat or cold weather. However, epoxy has some disadvantages, namely its brittleness, impact toughness and low flexibility, which limits its application in the automotive industry, which requires toughness [2].

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In the industrial era 4.0, manufacturing companies in the automotive industry began to reduce the use of metal (carbon steel) tending to use composite materials as exterior materials such as bumpers, extenders, other likes followers. The argument is, this material has unique characteristics such as low density, light weight, good resistance to corrosive environments, cheaper price and easier manufacturing process compared to metal materials such as carbon steel. Polyester matrix composite reinforced with natural fibers (ramie, cantula, banana stem) tensile strength, impact toughness is good when compared to using synthetic fiber reinforcement such as fiberglass, carbon fiber. Therefore, natural fiber-reinforced polyester composites have the potential to be developed as interior and exterior materials in the automotive manufacturing industry. In recent years, the use of natural fibers such as coconut fiber, sisal, hemp, bagasse, hemp, and pineapple fibers as reinforcement for polyester composite materials has accelerated, because natural fibers are a natural resource. Renewable nature and environmentally friendly natural fiber-reinforced polyester composites [3]. However, certain mechanical properties of natural fiber-reinforced polyester composites need to be improved, such as impact toughness, flexibility, ductility and heat resistance due to temperature degradation.

Epoxy modified rubber structural adhesive produces high strength and toughness [4]. Current commercial structural adhesives are modified epoxy with liquid reactive rubber carboxyl terminated butadiene acrylonitrile (CTBN). The addition of 10% by weight of CTBN can increase the fracture energy by a factor of 8 [5]. However, the CTBN method has several disadvantages such as difficulty controlling the concentration of rubber particles because it depends on the curing temperature, the concentration of rubber particles is limited to only 15% by weight, and has a high viscosity [6] But the addition of rubber particles alone decreases the tensile strength and modulus of elasticity these components [7], incorporating the applicable criteria that follow.

The urgency of the research is, the potential of Musa acuminata stems on the island of Lombok is very abundant, the community has not been able to use it optimally. They are considered as garbage that is thrown carelessly and this study is very urgent, the existence of agricultural waste in the form of Musa acuminata stems on the island of Lombok is very much. People use it only as compost, a mixture of animal feed. They are considered as useless material scattered along the rice fields so that the environment is polluted [8]. Stem Musa acuminate is actually a biofiber containing lignin, hemicellulose and cellulose which can be used as reinforcing fiber for polyester matrix composites.

Characterization of physical and chemical properties, natural fibers for reinforcing polyester composites is very necessary so that a good interfacial bond occurs between the reinforcing matrix fibers. By characterizing the physical and chemical properties of the main molecules making up the fiber (cellulose, hemicellulose, lignin) it can be known, so that it can be adjusted to the type of binding matrix. As a result, the interfacial bond between polyester and natural fibers is imperfect/defective. Defects that arise such as debonding, agglomeration (clumping of polyester), the appearance of voids (voids) that reduce the mechanical properties of the polyester matrix composite.

Until now, there has been no research report on the mechanical properties of MASF-reinforced polyester matrix composite materials and CTBN fiber fillers written in the open literature. Therefore, this study used fiber samples from the outer layer of the pseudo stem Musa acuminata, and elastic CTBN filler. The goal is to increase ductility, fatigue toughness, natural fiber-reinforced polyester matrix composite, so that it can be applied to the tourist shipbuilding industry and the automotive industry.

2 Materials and Methods

2.1 Materials

The fiber is taken from the outer layer of the pseudo-stem banana species Musa acuminta, which is healthy and has been aged for 13 months and the fruit has been harvested. The Musa acuminata tree was taken from Tanjung, North Lombok Regency, West Nusa Tenggara, Indonesia, as shown in Fig. 1. Matrix used, polyester type methylethylketone peroxide (MEKP), hardener HY-951, Caustic soda and water repellent (Nuva® N2114 liq.) and CTBN. All chemicals used in this study were laboratory grade file.

2.2 Methods

In this study before testing, the specimens were treated alkali, because the newly extracted MASF still contains various impurities such as fat, wax, pectin and so on. To remove these impurities, the MASF was immersed in 5% NaOH solution, for 24 h at room temperature (alkali treatment). The fibers are rinsed with clean water and dried again after alkaline treatment. Specimens were made with 80% fixed polyester volume fraction, three variations of MASF volume fraction: 20%, 15%, and 5%, CTBN volume fraction three variations: 0%, 5%, and 10%.

The mechanical properties, tensile strength of specimens were obtained using Grafil Test Method 101.13 on an Instron 1026 universal testing machine (serial H2709) 2with an Instron 2511–101 500 g load cell (serial number UK953, calibrated with 50 g weights) at a cross-head speed of 0.5 mm/min. Specimens for composite tensile test using ASTM D 3039 standard.

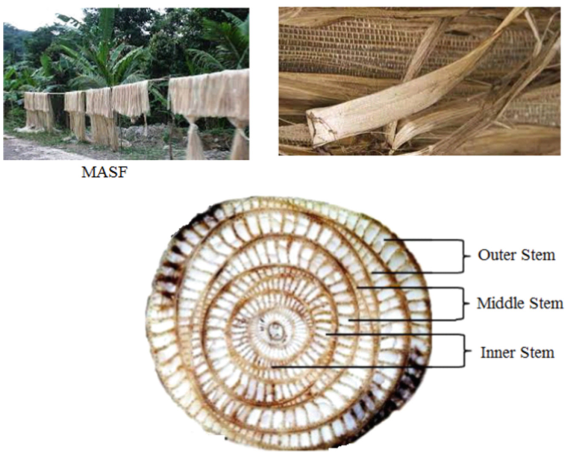


Fig. 1. Musa acuminate stem fiber (MASF).

To determine the impact toughness, an impact test was carried out using the Izod method, using a Pendulum Impact Tester, brand ZwickRoell with a maximum energy capacity of 750 J. Specimens for impact test using ASTM D 256 standard.

3 Results and Discussion

3.1 Tensile Strength Analysis

From the tensile test results Fig. 2. It is seen that there is a decrease in stress and an increase in tensile strain, due to the addition of the CTBN volume fraction. Decrease in tensile stress: 40.38 N/mm^2, 36.38 N/mm^2, and 28.43 N/mm^2, increase in tensile strain: 5.96%, 7.42%, and 9.12% respectively occurred in addition of fraction CTBN volume: 0%, 5% and 10% respectively.

3.2 Impact Toughness Analysis

Based on Fig. 3. The results of the impact test show an increase in impact energy and impact toughness, due to the addition of the CTBN volume fraction. The increase in impact energy: 0.414 J, 0.614 J, and 1.04 J, the increase in impact toughness: 0.005 J/mm^2, 0.008 J/mm^2 and 0.013 J/mm^2 occurred with the addition of the CTBN volume fraction: 0%, 5% and 10%, respectively.

3.3 Scanning Electron Microscopy (SEM) Analysis

Scanning Electron Microscope (SEM) testing of the specimen surface is carried out before tensile and impact testing. The aim is to determine the bond structure of the composite material, between reinforcing fiber (MASF), filler (CTBN) and polyester as matrix (Fig. 4).

Figure 5 is the fracture form of the SEM test results after the impact test. Specimens with a volume fraction of 0% CTBN. The type of fracture that occurs is the pull out

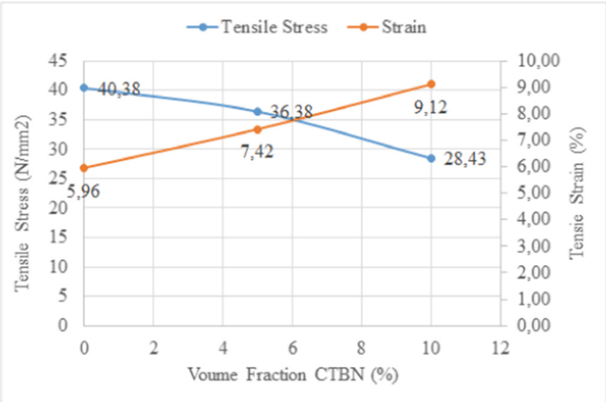


Fig. 2. Effect of addition CTBN on the tensile stress and strain changes

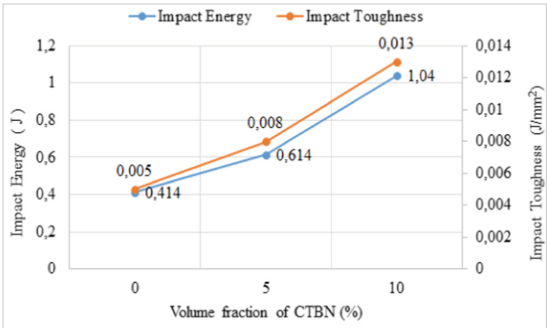
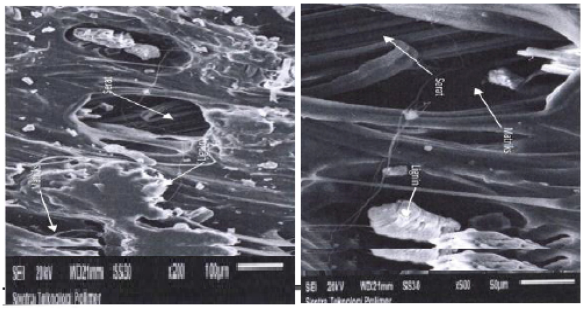


Fig. 3. Effect of addition CTBN on the impact toughness changes.



a b

Fig. 4. The morphology of the microstructure surface specimen, a. 0% CTBN, b. 10% CTBN. Source [5]

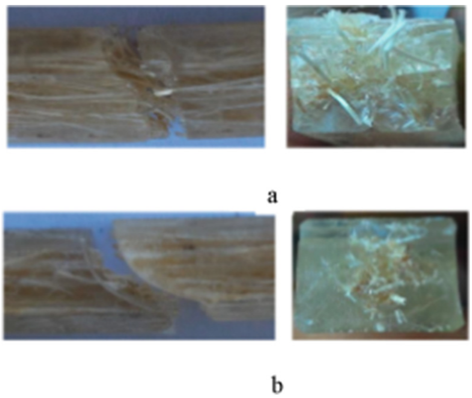


Fig. 5. The morphology of the microstructure impact test results, a. 0% CTBN, b. 10% CTBN

fiber type as shown in Fig. 5a. Pull out fiber is a condition where the fiber comes out at the fracture due to a less strong bond between the matrix, filler and fiber. Both faults are caused by the presence of voids around the fiber. Specimens with a volume fraction of 10% CTBN the fractures that occur are ductile fractures, broken fibers, with the direction of crack propagation being perpendicular to the direction of the working tensile stress. Broken fiber is a fracture in the specimen where the fiber is broken or damaged and forms like a fiber. The bond between matrix, filler and fiber is good, as shown in Fig. 5b.

4 Conclusion

The addition of CTBN increased the tensile strain and impact toughness, although it decreased the tensile stress of the specimen. Based on the results of the SEM test, there was no fiber pull out fracture in the specimen with CTBN, because the bond between the matrix, filler and fiber was very good.

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