The effect of fiber volume fraction on tensile and impact properties of *eleusine indica* grass reinforced polypropylene bio composite

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Abstract. The purpose of this research was to investigate the tensile strength and impact strength of eleusine indica grass fiber-reinforced polypropylene recycle composite. In this study, the fiber was treated with alkali at 5% NaOH for 2 hours. The eleusine indica grass fiber cut with a length of 3 cm and the matrix used recycle polypropylene. In this research, the volume fraction of eleusine indica grass fiber varied by 20%, 25%, and 30% respectively. The composite molded with a hot press at temperature 200°C with a holding time for 2 hours. Tensile test used ASTM D3039 and impact test used ASTM D256. The highest tensile and impact strength results on fiber volume fraction 30%.

1. Introduction

For the past decade, most manufacturing industries have been interested in developing eco-friendly products. The material of the developed product must be lightweight, widely available, easily biodegradable in nature, contain no hazardous and non-toxic materials. In the field of industry, natural fibers are being used to replace glass fiber. The advantages of natural fiber include easy to extract, light, renewable natural resources, decompose in the environment [1]. In particular, there is a great need for natural fiber in the automotive sector where the use of natural fibers in the vehicle body will reduce vehicle weight thereby impacting better fuel efficiency without sacrificing performance. There has been considerable research on the use of natural fibers as reinforcement in polymer matrix composites to replace synthetic fibers [2, 3, 4]. Synthetic fibers have been widely used in the industrial world, but synthetic fibers have the disadvantages; expensive, does not decompose in nature, high energy consumption, causes problems such as environmental pollution, skin irritation, and abrasion of equipment during processing. The increasing need for natural fiber composites required new natural fiber research as a reinforcement material for use in various applications and also as a hybrid composite. The natural fibers of the extracted plant generally grow in varying regions and environments. Soil conditions, climate, age, plant parts (roots, stems, leaves, fruits) determine the chemical content and other important properties of the fiber [5]. However, the characteristic of the most important amplifier is the adhesion property between fiber and matrix. Therefore, it is necessary to identify new natural fibers that have good physical and mechanical characteristics. Adhesion between fiber and matrix determines the quality of the composite. Natural fibers contain layers of lignin, hemoelulosa, waxes that wrap cellulose, this layer which inhibits the bond between the matrices with the fiber. To reduce the layers it is necessary to do chemical treatment so that the surface structure of the fibers becomes coarser so that it has good adhesion properties between the fiber and matrix. Chemical treatments are mostly done by some researchers is to use a solution of NaOH. In general, natural fiber treatment process using NaOH is easy to process, low cost and good result. Chemical treatment of each fiber varies, specific to each fiber. The percentage of NaOH varies from 1% to 20%, as well as the duration of immersion varies from 15 minutes to 24 hours [6-8].
The matrix used in biocomposites can be of thermoplastic or thermosetting polymers. The type of thermosetting polymer that is often used is epoxy. The disadvantage of polymer thermosetting is that it cannot be recycled, has a bad impact on the environment, because plastic waste cannot be degraded, causing CO₂ emissions and producing toxic gases when the material is burned. The type of thermoplastic polymer that is often used as a product in the industrial world is polypropylene. One of them is a plastic glass of mineral water. Some researchers have conducted research using polypropylene type plastic waste combined with natural fiber. Polypropylene is used as a matrix in composites because it can accept various types of reinforcing materials, such as glass fibers, glass balls, talc, asbestos, mica, calcium carbonate, and silica. Polypropylene also has a structure that can melt and be reformed several times.

Several studies have been conducted, among others, the use of polypropylene plastic waste combined with various kinds of natural fibers to be used as biocomposites, and the mechanical properties of the composites produced are close to the mechanical properties of glass fiber composites [9]. Other studies on the characteristics and mechanical properties of polypropylene plastic waste composites reinforced with coco fiber [10], palm fiber [11], sisal fiber [12], hemp fiber [13], and kenaf fiber [14]. Coconut fiber filters [15], corn husk [16]. In this study, Eleusine indica fiber was used as a reinforcement for polypropylene recycle composites.

2. Method

Eleusine indica grass is soaked with the water retting process for 7 days, then the fiber is extracted manually. The fiber is dried for 2 days in the open air, then oven for 2 hours to reduce the moisture content. The initial treatment of fiber uses 5% alkaline solution for 2 hours, then the fiber is rinsed with running water. Eleusine indica fiber is dried in an oven, until the moisture content is stable. Fiber is cut to 3 cm in size. Polypropylene recycle used comes from a drink with a certain brand. Polypropylene recycle is cut into small pieces, then cleaned with running water. The next process is drying for 1 day. Fiber density is calculated using a picnometer method. The volume fraction of fiber used is 20%, 25%, 30% respectively. The process using a hot press, with a temperature of 200°C with a holding time of 2 hours. Testing of tensile strength using ASTM D-3039 and impact strength testing using ASTM D256. SEM is needed to see morphology microstructure of fiber bonds with matrix.

3. Results and discussion

3.1. Tensile Strength

The results of the composite tensile strength testing are illustrated in Figure 1. The tensile strength of the composite at volume fractions of 20%, 25%, 30% is 13,465 Mpa, 16.01 MPa, 18.5 MPa respectively. The tensile strengths at 30% V_f were 37% greater than those of the materials prepared with 20% V_f. From the graph it can be seen that the trend of tensile strength increases with increasing volume fraction of fiber. In the 30% fiber fraction, the adhesion bond between the fibers with the best matrix, the polypropylene matrix fills the cavity between fibers and forms a good adhesion bond. In the volume fraction of 20% the lowest tensile strength fiber, polypropylene as a filler is too much compared to fiber, thus allowing the gap between fibers. This results in reduced composite ability to accept tensile loads.

![Figure 1. Tensile strength of composite](image-url)
3.2. Impact Strength

The results of the composite impact strength testing are illustrated in Figure 3. Impact strength composite at volume fractions of 20%, 25%, 30% at 0.005 Nm/mm², 0.029 Nm/mm², 0.041 Nm/mm² respectively. The increase in impact strength is 666% from a volume fraction of 20% to a volume fraction of 30%. The adhesion bond is very good at a 30% volume fraction, the polypropylene matrix binds fibers well so that the impact load is well distributed to the fiber. At a volume fraction of 20% the impact strength is very low because there is a cavity between fibers, as a result the load cannot be passed to the fiber. From the SEM photos, microstructure of composite morphology in the volume fraction of 20% contains many cavities, this is because the adhesion bond is less than perfect between the fiber and the matrix. At a 30% volume fraction, there is a fracture pattern with little cavity, a sign that the adhesion bond between fiber and matrix is very good.
4. Conclusions
The higher the fiber volume fraction increases the tensile strength and composite impact strength. In the 30% volume fraction, the adhesion bond between the fiber and the matrix is the most optimal, tensile load and impact load is well distributed to the fiber. From microstructure of composite morphology using SEM, visually visible fracture surfaces are more evenly distributed at 30% volume fraction. The bond between fiber and matrix is very good, with fewer cavities than the fracture surface at a volume fraction of 20%

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