The effect of corn stalk fiber loading on tensile properties and absorption ability on polybutadiene adipate terephalate composite.

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Abstract. The natural fiber have recently become attractive and been widely used as reinforcement material to replace synthetic fiber as a concern to environmental issue. However, there are some of natural fiber unable to perform well as reinforcement material due to their natural properties. In this research study, the corn stalk fiber was selected as natural fiber reinforced with polybutadiene adipate terephalate (PBAT) to form bio-composite materials. There are two type of PBAT used which are in pellets form and powder form. The objectives of using different type of PBAT are to identify their compatibility with filler and the dispersion of corn stalk fiber in both forms of matrix. Then, the both type of PBAT also compounded with difference loadings of corn stalk fiber. Lastly, their effect on tensile properties and absorption ability were identified. After the test is run, the composite of neat PBAT in powder form shows highest tensile strength and elongation at break but lowest in water absorption percentage compared to others. However, the composition of pellets PBAT with 30wt% of corn stalk fiber shows highest percentage of water absorption compared to others.

1. Introduction

Natural fiber also known as bio-fiber have been extensively used by researcher around the world in recent years. This is due to their collective valuable unique properties which includes low density, light weight, affordable cost, highly availability, recyclable, non-toxicity, eco-friendly, good thermal stability, lower abrasion of equipment during processing and bio-degradability [1]. Therefore, they have potential to use as reinforcement material to replace synthetic fiber in producing of green composite [2]. There are several example of natural fiber widely used as natural fiber are paddy straw, corn stalk fiber and sisal [3]–[5].

Usage of corn stalk fiber as reinforcement materials were increase day by days. They are highly available and categorized as hydrophilic materials because have large amount of porous cells making them excellent in absorption [6]. They were collected from agricultural-based industries which release to the environment without proper disposal procedure causing pollution and harmful effect on human and animal health [7]. Thus, the usage of corn stalk fiber were not only replacing conventional synthetic fiber, but also may help preventing environment pollution.

Polybutadiene adipate terephalate (PBAT) is one of bio-polymer. They are synthetic polymer based on fossil resources with high elongation at break and very flexible [8]. The PBAT commonly used in packaging fields and medicine application by blending with other polymer such as natural rubber (NR), polycaprolactone (PCL), poly(propylene carbonate) (PPC) and mostly blend with polylactic acid (PLA) [9]–[13]. However, there are less studies conducted by researcher before about the production of
composite materials using PBAT with natural fiber. This is because the PBAT is relatively expensive [14]. Therefore one approach to reduce the cost of PBAT composite is to compound them with low cost natural materials such as natural fiber.

In this research study, there are two type of PBAT was used which are in pellet form and powder form to investigate their compatibility and dispersion with corn stalk fiber. The PBAT then compounded with varying corn stalk fiber weight which are 10wt%, 20wt% and 30wt% to evaluate their effect on different composition. The tensile properties and absorption ability in water of all specimens were investigated and compared among fiber loading and both types of PBAT form ad matrix.

2. Methodology

2.1. Materials

The natural fiber used in this study was corn stalk fiber taken from pith part (see figure 1). The corn stalk fiber used were randomly collected after harvesting by local farmer in Perlis, Malaysia. Furthermore, they were cleaned by using distilled water to remove dirt and dried by exposed to sunlight. Lastly, the corn stalk fiber was grinded by using a grinder and ready for compounded with bio polymer. The polymer used as a matrix to form bio-composite in this research is PBAT in pellet form and powder form as shown in figure 2.

![Figure 1. Corn stalk fiber from pith part.](image1)

![Figure 2. Two type of PBAT used.](image2)
2.2. Compounding
The two types of PBAT (pellets and powder) were supplied by Jiangsu (China) compounded with corn stalk fiber to form composite by using the heated roll mill and compression moulding followed composition in Table 1. The temperature used for heated roll mill used are 120˚C with rotor speed is 6 rpm. However the temperature used for compression moulding also 120˚C and the process within 10 minutes with pressure at 170 kg/cm².

| Type of PBAT | Composition |
|--------------|-------------|
|              | PBAT, wt%   | Corn stalk fiber, wt% |
| Powder       | 100         | 0                   |
|              | 90          | 10                  |
|              | 80          | 20                  |
|              | 70          | 30                  |
| Pellet       | 100         | 0                   |
|              | 90          | 10                  |
|              | 80          | 20                  |
|              | 70          | 30                  |

2.3. Characteristics
The tensile properties of the specimens was conducted by using a Universal Tensile Machine (UTM). The specimens were cut into dumbbell shape about 50 mm according to ASTM 638. The tensile test was performed with cross head speed of 50 mm/min at room temperature [15]. The absorption ability testing was conducted to prove the abilities of PBAT compounded with corn stalk fiber to absorb water and provide hydrophilic properties. The specimens with measurements of 20 mm x 20 mm x 1 mm were used as indicated by ASTM D570-98. Before testing, the specimens was dried by using vacuum oven to remove moisture content that may affected by environment. After drying process, the initial weight of the specimens then measured and recorded by using electronic weight balance. The specimens then immersed in water and weighed for everyday until equilibrium readings. After weighed, the specimens were calculated using the following equation (1) [7];

\[
\text{Water Absorption (\%)} = \frac{W_2 - W_1}{W_2} \times 100\% \tag{1}
\]

Where, \(W_1\) refer to the initial weight of corn stalk fiber and \(W_2\) refer to the final weight of corn stalk fiber.

3. Results and Discussion
The tensile properties PBAT matrix containing different loading of corn stalk fiber are presented in figure 3 and figure 4. Based on both figures, the ultimate tensile strength and the elongation at break was drastically decrease with increasing the composition of fiber in composite for both powder and pellets form of PBAT. The composites with 30wt% of corn stalk fiber shows the lowest tensile strength for both PBAT in powder form and in pellets form with reading 4.622 MPa and 4.609 MPa, respectively. This result was explain that the strength and elasticity properties of the composite were worsen by increasing the number of corn stalk fiber. This result happen due to the compatibility between the polymer matrix which are PBAT and corn stalk fiber was weak then unable give better mechanical properties to the specimens. Similar behaviour also been reported by Moustofa and teams (2017) in their research study involving PBAT and coffee grounds fiber [16].
The figure 3 and figure 4 also show that the higher tensile strength and elongation at break on the PBAT in powder form compared to PBAT in pellets form. The neat PBAT in powder form shows elastic properties with highest tensile strength and elongation at break with reading 17.944 MPa and 948.9% respectively. This results was prove that the PBAT in powder form tends to well mixed with the fiber during compounding compared to PBAT in pellets form. Nassar and teams (2021) also conduct the testing by using different type of polymer matrix, which are using powder and pellets Polypropylene (PP) then have similar behaviour in with this research study [17].

![Tensile strength of composite](image)

**Figure 3.** The comparison for tensile strength of PBAT compounded with corn stalk fiber.

![Elongation at break of composite](image)

**Figure 4.** The comparison for elongation at break of PBAT compounded with corn stalk fiber.
The water absorption results for PBAT compounded with corn stalk fiber after 30 days were shown in figure 5. The neat PBAT for both powder and pellets form show the lowest percentage of water absorption compared to others with reading 0.02% and 0.05% respectively. That result were obtained due to the PBAT are hydrophobic bio-polymer [16], [18]. Therefore they would not absorb the water. Then, the percentage of water absorption of the specimens were increase by increasing the composition of corn stalk fiber. This is because bio-filler are polar materials with hydroxyl group which will absorb water. Liu and teams (2019) also mention in their research study that the corn stalk fiber have hydrophilic lignocellulosic molecules making them can absorb water [2].

Figure 5 also shows that the PBAT composites in pellets form have higher water absorption percentage compared to PBAT in powders form. This result manifest that the PBAT composites in powder form exhibit better interfacial bonding between polymer matrix with polymer matrix and polymer matrix with the filler. Similar behaviour also been reported by Nassar and teams (2021) which comparing water absorption of specimens by using powder and pellets polypropylene, PP [17].

![Absorption Percentage after 30 days](image)

**Figure 5.** Absorption percentage of specimen after 30 days.

### 4. Conclusion

Based on investigation may conclude that the composition between corn stalk fiber with PBAT matrix may influence the tensile properties and water absorption abilities of the composites. Other than that, the type of PBAT used which are in powder and pellets form also can gives impact on the results in this research study. The neat PBAT in powder form show the highest value on tensile strength (17.944 MPa) and elongation at break (948.9%) due to the interaction only among the matrices particle, without any additives, filler and others. However the composites compounded between PBAT in pellets form and 30wt% of corn stalk fiber shows the lowest value on tensile strength (4.609 MPa) and elongation at break (6.5%) due to poor adhesion between polymer matrix and filler. This is because, higher filler loading will tends to decrease the interaction and adhesion between matric and filler. Therefore, there are further study should be conducted later to improve the compatibility of PBAT polymer matrix with corn stalk fiber such as chemical treatment or using coupling agent to achieve better tensile properties. For absorption ability testing, the neat PBAT in powder form shows lowest percentage of water absorption (0.02%) because of their hydrophobic properties and better interfacial bonding compared to neat PBAT in pellets form. The composites with PBAT in pellets form and 30 wt% of corn stalk fiber
showed the highest percentage of water absorption causes by hydrophilic lignocellulosic molecules on corn stalk fiber and poor interfacial bonding between polymer matrixes with the fibers.

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Acknowledgments
The authors would like to express their sincere thanks to the Ministry of Higher Education Malaysia (MOHE) for the research fund under the Fundamental research Grant Scheme (FRGS) of the Project Code: FRGS/1/2018/TK05/UNIMAP/02/3).