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## The Influences of Different Bamboo Filler Loading on Tensile Properties and Impact Strength of RHDPE/BF Composites

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# The Influences of Different Bamboo Filler Loading on Tensile Properties and Impact Strength of RHDPE/BF Composites

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**Abstract.** Recycled high-density polyethylene and high-density polyethylene reinforced with bamboo filler were compounded with twin-screw extruder and injection molding process. The main objective of this study is to investigate the effect of different loading of bamboo filler reinforced with recycled high-density polyethylene composites via injection molding. The fillers loading were reinforced with plastic for different loading which is 0 wt.%, 5 wt.%, 10 wt.%, 15 wt.% and 20 wt.% for two different matrixes, which is recycled high-density polyethylene and high-density polyethylene. Mechanical measurements will show the presence of different loading filler will insignificantly effect in the composites tensile strength and also impact. The result of the mechanical analysis carried out showed that the presence of natural filler in composites will improve the properties of the material.

## 1. Introduction

In recent years, there has been increasing attention to the application of biodegradable composites reinforced with natural fibers with the view towards economic incentives and environmental concerns [1] [2]. The advantages of plant-based fibers over traditional synthetic fillers are their lightweight, low cost, specific mechanical properties and excellent biodegradable properties. There is evidence that shows the presence of natural fiber in polymeric materials can enhance the performance of virgin materials [3].



Among many types of such materials, the bamboo fiber itself is a unidirectional reinforcing composite consisting of long and parallel cellulose fibers embedded in an amorphous matrix of lignin and hemicellulose [4], and then is recognized as one of the most attractive reinforcement fillers because of its excellent inherent properties [5] [6]. Furthermore, the inexhaustible supply and natural abundance of bamboo make it an excellent candidate for developing natural composites. Thus, the use of bamboo fibers as a reinforcing material in structural composites has gained popularity in the building and automotive industries [7] [8].

Plastics injection molding filled the need for quality of the product with the latest developments which made the industries to find for new methods for manufacturing and production of components with low cost. It is probably the most widely used cyclic process for manufacturing derived of polymers including fiber reinforced thermoplastics, elastomers, thermoplastics materials and thermosetting plastics. This processing technology is possible to fabricate excellent surface finish of complex geometric components with good dimensional and specification properties. [9] [10] [11].

In these research, recycled high-density polyethylene (RHDPE) and virgin high-density polyethylene (RHDPE) will act as matrix and bamboo fiber particle as the reinforcing filler in order to prepare a particle-reinforced composite. It is used to determine the mechanical properties of polymer composite according to filler content and to examine the possibility of using waste materials as reinforcing filler.

## **2. Experimental Procedures**

### *2.1. Matrix*

A matrix is a binder material that is used to hold fibers in position and transfer external loads to internal reinforcements [12]. The recycled high-density polyethylene (RHDPE) as the matrix will be supplied by Zarm Scientific and Supplies Sdn. Bhd. in solid pallet form with the melt flow rate of 0.236 g / 10 min at 200 ° C, 5 kg load.

### *2.2. Fiber Preparation*

The bamboo will be obtained abundantly around Perlis, Malaysia area. In this study, automatic hammer continuous grinder (HK-08B) will be used to reduce the particle size of bamboo. Then, the bamboo flour will be sieved based on the required size using a vibratory sieve shaker AS 200 controls before undergoing the particle size analyzer (Malvern Sciro 2000 Mastersizer) for the particle size confirmation.

### *2.3. Composites Preparation*

Different contents of bamboo flour will be used in this study according to the formulation in Table 1. The composites were prepared by compounding using the twin screw extruder with a barrel temperature of 170 ° C. RHDPE mixed with bamboo flour with different ratio will be loaded into the feeder and run through the twin screw extruder. Then, the pallets of composites will be produced. The composites pallet will undergo with injection molding process for the final product. The samples of the final product will be cut into shape according to the requirements of test conduct in this study.

**Table 1** The filler loading of the composites

Parameters	Materials	Formulation
Filler loading	RHDPE	RHDPE
	RHDPE / 5 wt.% BF	95 wt.% RHDPE / 5 wt.% BF
	RHDPE / 10 wt.% BF	90 wt.% RHDPE / 10 wt.% BF
	RHDPE / 15 wt.% BF	85 wt.% RHDPE / 15 wt.% BF
	RHDPE / 20 wt.% BF	80 wt.% RHDPE / 20 wt.% BF
	HDPE	HDPE
	HDPE / 5 wt.% BF	95 wt.% HDPE / 5 wt.% BF
	HDPE / 10 wt.% BF	90 wt.% HDPE / 10 wt.% BF
	HDPE / 15 wt.% BF	85 wt.% HDPE / 15 wt.% BF
	HDPE / 20 wt.% BF	80 wt.% HDPE / 20 wt.% BF

#### 2.4. Tensile Test

Tensile testing was performed using Axial-Torsion Universal Testing Machine (INSTRON-5982) at room temperature according to ASTM D638. In this study, all tensile specimens will be pulled under a constant crosshead speed of 50 mm/min and 50 mm gauge length. Before the test, the thickness of specimens will be measured using Vernier caliper. Five specimens will be conducted and the tensile strength values will be averaged to obtain a mean value.

#### 2.5. Impact Test

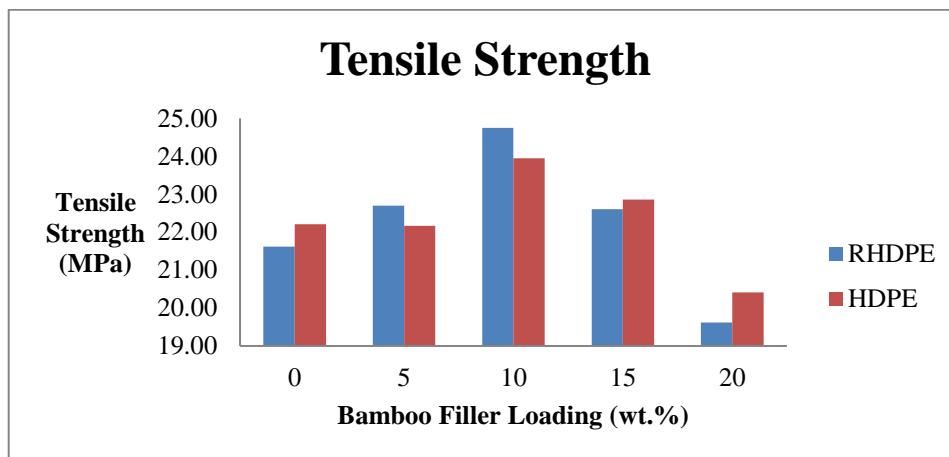
Charpy impact test was conducted according to ASTM 790 at room temperature by using Compact Charpy Impact Tester (Model MAT 23). From this test, the fracture energy (Joule) will be determined. Five specimens will be conducted and the impact energy values will be averaged to obtain a mean value.

### 3. Results and Discussion

#### 3.1. Tensile Properties

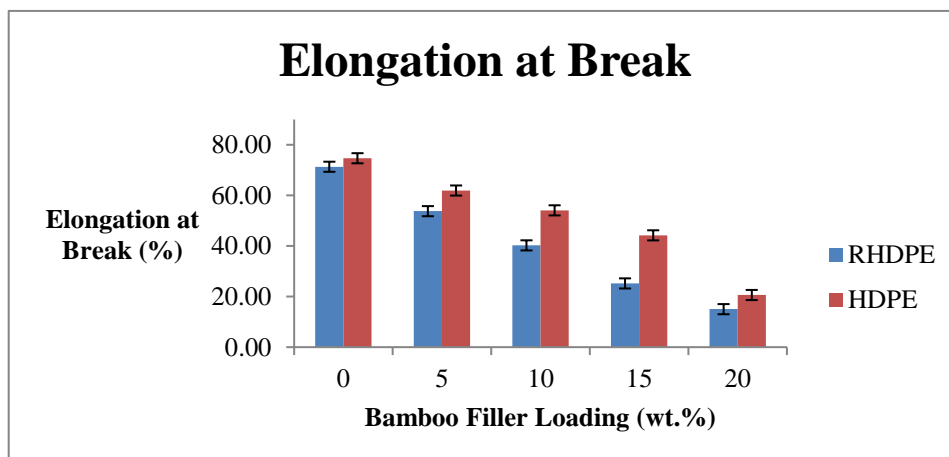
Figure 1 shows the effect of fiber loading on the tensile strength of RHDPE / BF composites and HDPE / BF composites. The results obtained from tensile strength indicates that increasing of fiber loading will increase the tensile strength from 5 wt.% until 10 wt.% and drop when 15 wt.% and 20 wt.% of fiber loading used. 10 wt.% of filler loading for both RHDPE and HDPE polymer give the highest result which is RHDPE / BF, 24.749 MPa while HDPE / BF, 23.944 MPa.

A great interface between RHDPE and HDPE matrix with BF fiber will improve tensile strength due to encourages of perfect stress transfer. A great tensile strength mostly depends on effective and uniform stress distribution [13]. Tensile strength starts to decrease at higher BF fiber loading respectively for both of different matrix used. The BF particles tend to agglomerate which will lead to insufficient wetting of filler by the small amount of matrix. So, fiber will give a negative effect which limits the tensile strength without a great fiber-matrix interfacial [14]. Apart from that, the decreasing of tensile strength with 15 wt.% and 20 wt.% BF fiber was possibly due to the presence of voids getting trapped in the composite during processing. So, a specific technique while preparation process of composites is required when dealing with high filler loading composite to make sure it has an excellent dispersion of fibers and great interfacial bonding [15].



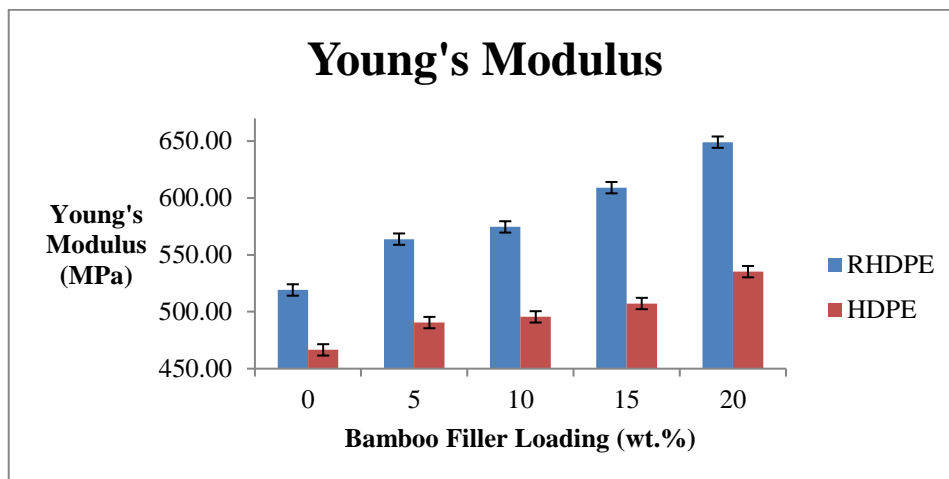
**Figure 1.** Effect of different filler loading on tensile strength.

Figure 2 shows the elongation at break of RHDPE / BF composites and HDPE / BF composites with different fiber loading. The elongation of break results decreased with increasing amount of BF fibers regards of the brittle nature by BF in the composites that indicated a decrease polymer matrix ductility with the presence of BF fibers [14] [16]. Thus, it is proved that a strong but brittle RHDPE / BF and HDPE / BF wood polymer composites are produced due to lower values of elongation at break which is the cracks travel through weaker interfacial regions [15] [17].



**Figure 2.** Effect of different filler loading on elongation at break.

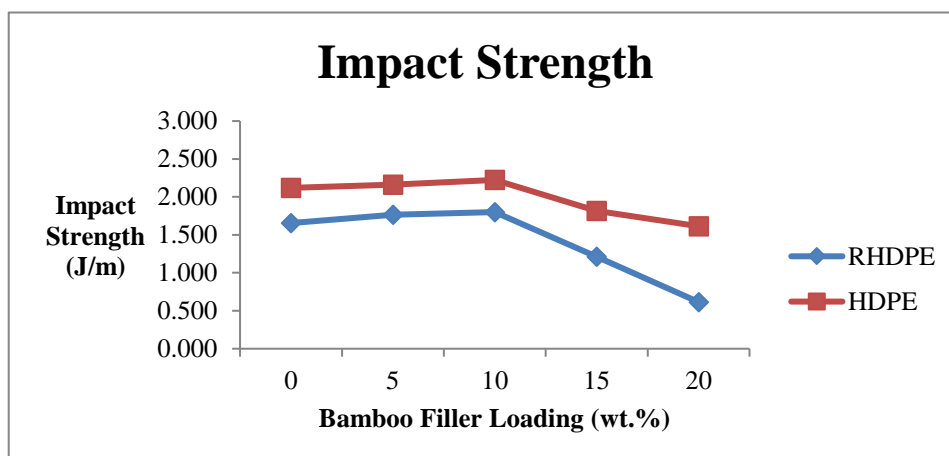
The Young's modulus of RHDPE / BF composites and HDPE / BF composites with different fiber loading is shown in Figure 3. The results showed that increasing of BF fiber will give positive influence of Young's modulus for composites, compared with the pure polymer, RHDPE and HDPE. Modulus of composites was enhanced with the addition of BF fiber due to increasing restrictions on the movement of polymer molecules. These results indicate that higher fiber loadings will increase Young's modulus by the intrinsic property of high stiffness of BF [17]. In this study, the values of Young's modulus decrease at 5 wt.% of BF filler and gradually increase with highest values obtained at 20 % of BF for both of the RHDPE / BF and HDPE / BF composites.



**Figure 3.** Effect of different filler loading on Young's modulus.

### 3.2. Impact Properties

Impact properties will determine the ability of a material to withstand an impact load, which ability depends on materials toughness [18]. The effect of increasing filler loading on the notched impact of RHDPE / BF and HDPE / BF composites is shown in Figure 4. The highest impact strength for both of material at 10 wt.% filler content and then it keeps decreasing with increasing of filler content. The lowest impact strength is 20 wt.% of filler loading for both composites. The strength of composites increases with filler loading up to 10 wt.% due to the ability of composite to absorb energy favorable entanglement of filler and matrix [19]. This strength slumps with excessive increasing of filler loading from 15 wt.% to 20 wt.% due to the reduction of elasticity of material when filler was added. So, it will reduce the deformability and ability of the matrix to absorb energy which reducing the toughness [20].



**Figure 4.** Effect of different filler loading on impact strength.

## 4. Conclusions

In conclusion, it has revealed that bamboo act as natural filler to produce polymer composites and create new composites materials with great properties and save cost with the ability to reduce environmental problems. The additional bamboo filler in composite increase the tensile strength and tensile Young's modulus. The tensile elongation at break declines with increasing of filler loading. The impact strength also shows improvement with the optimum result at 10 wt.% of filler loading.

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