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Effect on Mechanical Properties of Hybrid Blended Coconut Coir/Paraffin Wax/LDPE

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Abstract: The use of natural fibers as the fillers for plastic has been rapidly expanding, especially wood fibers. This is due to materials of wood offers many advantages as inorganic fillers (such as low price, biodegradability, renewability, recycle-ability, low density and others). In addition, this is also due to the dramatic increasing of interest of using biomass materials as the replacements for glass fiber into reinforced thermoplastic composites. In this study, wood plastic composites used are the filled thermoplastics which primarily consisted of wood fiber and thermoplastic polymer. While, the purpose of this research is to find out the optimum conditions of the wax and coconut coir produced by inducing LDPE. The experiment carried out is by mixing the wax, coconut coir and LDPE into eight new polymer compositions, in which the higher value of the tensile strength and hardness are obtained by mixing between 6 wt. % coconut coir with 4 wt. % wax, rather than to pure LDPE, that is 9.236 MPa and 3HV. Although the strength impact is decreased with value as much as 60.95 % compared to original conditions, the SEM analysis proved that the composition of 90 wt. % LDPE, 4 wt. % wax and 6 wt. % coconut coir is the best weight ratios for mechanical characteristics and bonding between reinforced material and matrix material. Here, the LDPE, wax and coconut coir mixture produces a new hybrid polymer and alters the properties of pure LDPE.

Keywords: LDPE; paraffin wax; coconut coir; optimum conditions; new hybrid polymer

1. Introduction

Polymer is a long chain of repeated atoms and produced by joining the molecules which are known as monomers. The Low Density Polyethelene (LDPE) is a first grade of the Polyethylene group which was produced in 1933 by Imperial Chemical Industries by using high pressure and 'free radical polymerisation' techniques [2], while the wax is an organic compound which is categorized into two types, that is natural wax and modified wax. Both types of wax create higher potential as the reinforcement agent in polymers. Coir is a fiber that covers the entire palm. Prior to the lack of *abaca* in the early 19th century, coir is a key ingredient used by European manufacturers because of the rope coir rope light, high tensile force and resistance to sea water [4]. Coconut shell is one of the most important natural fillers. Many works have been devoted to use of other natural fillers in composites in the recent past and coconut shell filler is a potential candidate for the development of new composites because of their high strength and modulus properties [8]. Composites of high strength coconut filler can be used in the broad range of applications as, building materials, marine cordage, fishnets, furniture, and other household appliances [10]. Scientific studies involving coir fibers date back to the early 1980's while the majority of the work in this area has been done in the past 10 years [7]. The reason to choose the natural wax and coconut coir in this research due to the cost of manufacturing as well as it widely used for consumer products [6].

2. Material and Method

This research use low density polyethylene as the matrix material in the form of pallet and the wax and coconut coir as reinforcement material. The wax material was obtained from the candle sticks that have been processed by the manufacturers. Chemically, a candle contains of various compounds such as alkanes, esters (contains acid and alcohol), polyesters, low hydroxyester alcohol, and fatty acids. The wax differs from fat because it lacks triglyceride ester glycerine propan 1,2,3 triol and three fatty acids. High melting point and hardness of *karnauba* candle occurs when ester is added [1].

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Coconut coir fiber was used in this research. Peel the coconut skin and then dried under the sun for two days. Next process is the precipitate was filtered and then dried in the oven at 80 ºC for 24 hours.

The formulation for LDPE, wax and coconut coir is divided into eight main compositions ratio as shown in Table 1. Every material is mixing into a beaker and the compound was compress for 15 minutes under 20 tonnes at temperature of 150 ºC followed by cooling at room temperature.

Table 1. Compositions ratio of LDPE, wax & coconut coir.

Compositions	LDPE (wt. %)	Wax (wt. %)	Coconut coir (wt. %)
1	100	0	0
2	90	10	0
3	90	8	2
4	90	6	4
5	90	5	5
6	90	4	6
7	90	2	8
8	90	0	10

By using crusher machine, the compounds are processed into particle size 2 mm x 2 mm. This process is to ensure that both of the materials are uniformly mix and no lumps presence due to the smaller lumps are able to influence the accuration of data analysis. The LDPE, wax and coconut coir compound was compressed again in hot press with same parameter. The final products were in the form of plates with dimensions of 260 mm x 260 mm x 3 mm and prepared for cut into ASTM standard and conduct mechanical testing. Eight types of new polymer composition are cut and tested for tensile, harness, and charpy characteristics according to ASTM D-638 08, ASTM E-384 and ASTM D-6110 08 respectively. The microscopic observation is carried out to observe the cracked surface after all of the LDPE, wax and coconut coir polymer subjected into three mechanical testing. Here, the morphology of the cracked surface is observed by using scanning electron microscopy (SEM) at three types of magnifications that are 25X, 50X and 100X, which consists of topographical, morphological and composition pictures.

3. Results and Discussion

Tensile test

The test for tensile strength test is being done against the seven major compositions of the mixture with the percentage of LDPE, wax and coconut coir in between 90 wt. % to 2 wt. %. This refers to the objective priority of the research that is to find the higher value of tensile strength for the LDPE, wax and coconut coir composition of the manufacturing process. The LDPE 90 wt. %, wax 4 wt. % and coconut coir 6 wt. % mixture was observed and the tensile strength is higher compared to the other wt. % compositions. The addition of 10 wt. % of wax and coconut coir shows a pattern of increase in its tensile strength and modulus tensile compared to pure LDPE. But, the addition of 10 wt. % wax and 10 wt. % coconut coir caused a decreasing pattern of the tensile strength data, compared to combined wax and coconut coir. However, while the wax and coconut coir is further decreased from 6 wt. % to 4 wt. % then the tensile strength will increase [12] – [15]. The result is as shown in Fig.1a and Fig.1b.

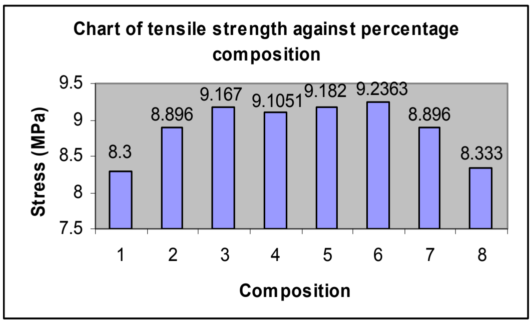

Fig.1a. Chart of tensile strength against percentage composition of LDPE, wax & coconut coir.

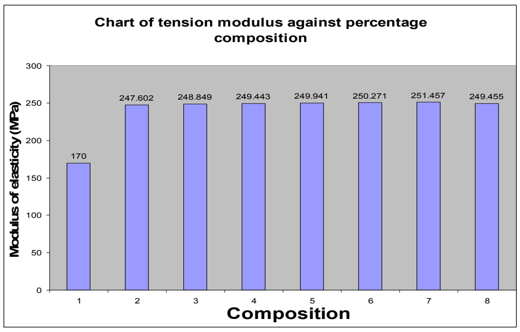

Fig.1b. Chart of tension modulus against percentage composition of LDPE, wax & coconut coir.

Hardness test

The high hardness value of the mixture shows the property of the material, which has high hardness level. The hardness value of 10 wt. % wax is 1.5 HV and 10 wt. % coconut coir is 1.75 HV, meanwhile the value for 4 wt. % wax and 6 wt. % coconut coir is 3 HV. The significant differences in the value shows that the high percentage of wax and coconut coir will decrease the hardness of the material as the bonding between the molecules become irregular. Comparison is also done between pure LDPE and 90 wt. % LDPE and it shows that the hardness value of pure LDPE is lower than 90 wt. % LDPE, which is between 1.5 HV to 1.75 HV. The ductile property of pure LDPE is unable to withstand hardness. The hardness value of pure LDPE and composition LDPE, wax and coconut coir are calculated and shown clearly in Fig.2a.

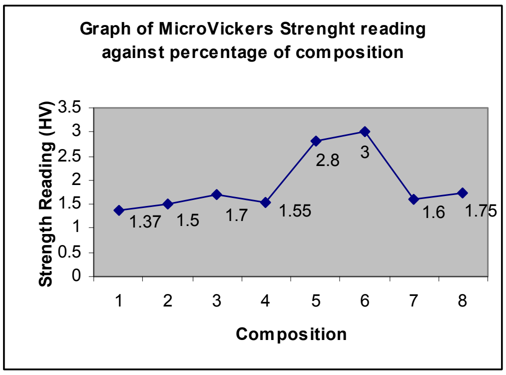

Fig.2a. Graph of Microvickers strength against percentage composition of LDPE, wax & coconut coir

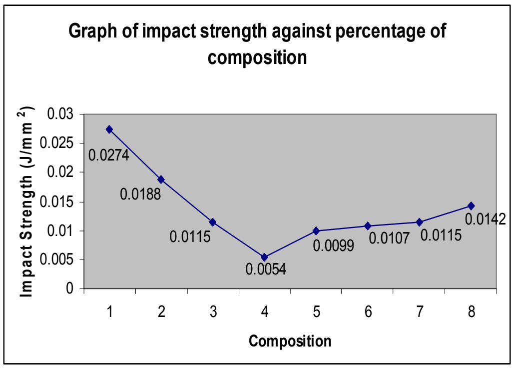

Fig.2b. Graph of Impact Strength against percentage composition of LDPE, wax & coconut coir

Charpy impact test

Fig.2b proven that the LDPE, wax and coconut coir are lower than pure LDPE. Theoretically, pure LDPE has high ductile strength and elasticity. From 10 wt. % wax mixture, the value of energy absorbed is close to pure LDPE, but lower for the other mixtures, the value has decreased, while in 10 wt. % coconut coir mixture, the value increases but it is lower compared to pure LDPE [3].

Surface morphology of cracked specimens

The analyses towards surface morphology of the broken specimens carried out by using scanning electron microscope after the tensile testing. The morphology is used to identify the bonds between the LDPE, wax and coconut coir structures. It is also used to find the changes on the material after being tested with a strong tensile strength.

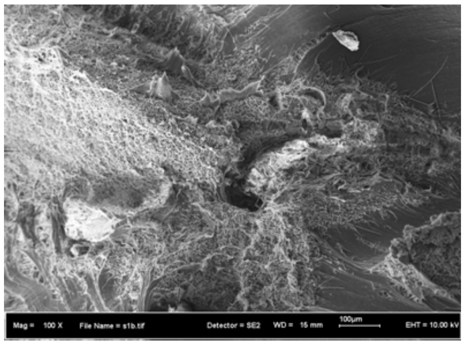

Fig.3a. Magnification at Mixture of 90 wt. % LDPE & 10 wt. % wax.

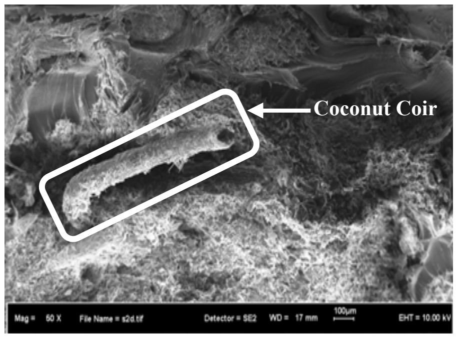

Fig.3b. Magnification at Mixture of 90 wt. % LDPE, 8 wt. % wax & 2 wt. % coconut coir

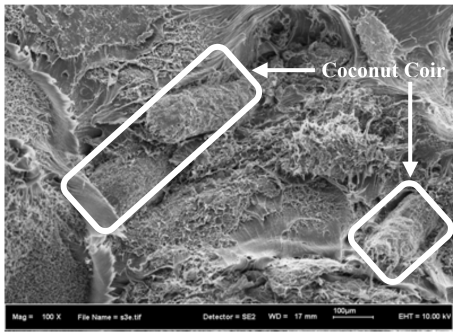

Fig.4a. Magnification at Mixture of 90 wt. % LDPE, 6 wt. % wax & 4 wt. % coconut coir

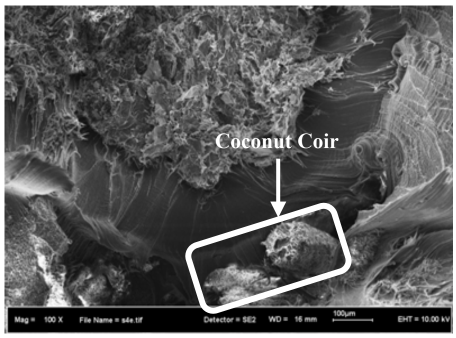

Fig.4b. Magnification at Mixture of 90 wt. % LDPE, 5 wt. % wax & 5 wt. % coconut coir.

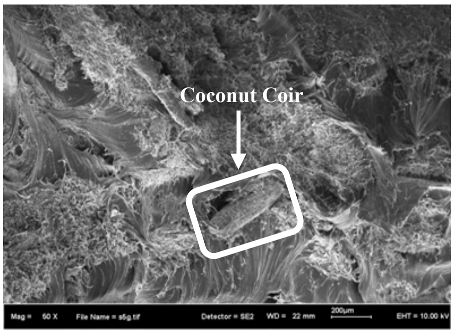

Fig.5a. Magnification at Mixture of 90 wt. % LDPE, 4 wt. % wax & 6 wt. % coconut coir.

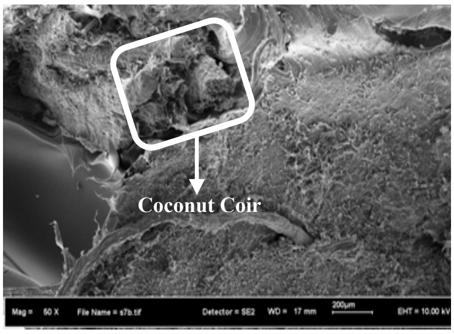

Fig.5b. Magnification at Mixture of 90 wt. % LDPE, 10 wt. % coconut coir.

Fig. 3a shows the LDPE 90 wt. % has covered the borders and most of the area. Fig. 3b until 5a shows 8 wt. % to 2 wt. % of wax and coconut coir. Fig.5b shows that LDPE and coconut coir cover the area.

4. Summary

Based on the mechanical properties results (which is obtained from the tensile strength test and hardness test), it is known that the mechanical characteristics of LDPE increases. However, its decreases when the impact test is done. This shows that the mixture is hard, but it is more ductile compared to pure LDPE.

Based on the observation, the best wt. % mixture for these three materials is 90 wt. % LDPE, 4 wt. % wax and 6 wt. % coconut coir. This weight ratio has increased the mechanical characteristics [11] of the pure LDPE. The morphology test on the broken surface shows that the adhesion between wax, coconut coir and LDPE is a strong bond. But if the mixture is unproportional, then the LDPE characteristics will decrease.

The research also shows that is a part of increasing the strength against an object, LDPE also able to increase the income due to wax and coconut coir are less expensive and readily available [9]. The usage of injection moulding process will also improve because the wax acts as a conductor during this process.

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