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A Comparision Analysis on Mechanical Properties between Wax/LDPE Composite Versus Coconut Coir/wax/LDPE Hybrid

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***Abstract*— Natural fibers are, currently, as one of potential's reinforcing fiber source. One of their potential, especially which is related to mechanical reinforcement, can be found in coconut coir. By adding wax and low density polyethylene as reinforced matrix to coconut coir, in fact, will enhance the mechanical properties of the resulting hybrid composites. Therefore, in order to find out the optimum properties of coconut coir, this study is focused on how the mechanical characteristic of coconut coir and wax produced by inducing LDPE. In this study, by mixing the coconut coir, wax, and LDPE into four new polymer compositions, we found that the higher value obtained of the tensile strength, and hardness is by mixing between 8wt. % coconut coir with 2 wt. % wax hybrid, while for impact test LDPE/wax composites showed significantly higher impact. With two different methods applied, we carry out the study through hot plate magnetic stirrer for wax and LDPE mixing, while to coconut coir, wax, and LDPE with hot press. By examining the results related to mechanical properties value, we found that the most suitable mixtures of an optimal composition is obtained with 90 wt. % LDPE, 4 wt. % wax, and 6 wt. % coconut coir. Here, the LDPE, wax, and coconut coir mixture produces a new hybrid polymer.**

***Keywords* - LDPE; paraffin wax; coconut coir; optimum conditions; new hybrid polymer.**

I. INTRODUCTION

Recently, natural fibers have been attracting the attention of researchers due to their advantages to provide over conventional reinforcement materials, such as low cost, renewability, biodegradability, low specific gravity, abundancy, high specific strength, and non-abrasiveness [1]. Viewing on this reason, especially coconut, many works have been devoted to use this natural filler in composites in the past and recent years.

First, coconut shell which is one of the most important natural fillers and as a potential candidate for the development of new composites due to their high strength characteristics and modulus properties [2, 3, 4,5,6]. Second, coconut coir as a fiber contained that cover the entire palm .

Historically, 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 [7,8,9].

Both of natural fibers aforementioned are the composites made of polymeric materials are being used in many applications, such as industrial, construction, marine, electrical, household appliances, automotive and sporting goods. [10].

Therefore, this paper will focus on investigation of LDPE/ wax composite and LDPE/wax/ coconut coir hybrid and compare the mechanical properties. Finally evaluate the best composition among matrix and reinforcement.

II. MATERIALS AND METHODS

- *Wax*

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. The natural wax, we can get from the animal and vegetable waxes, i.e. beeswax, wool wax, and cotton wax. While, the mineral waxes (that even more in our common daily life), we can found from petroleum waxes in especially i.e. paraffin wax and microcrystalline waxes.

In this research, the wax material used is the candle sticks processed by the manufacturers, which are chemically, 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. The high melting point and hardness of carnauba candle occurs when ester is added [11,12].

- *Coconut coir fiber*

The coconut coir fiber used in this research is prepared by peeling off the coconut skin and then dried under the sun for two days.

Then, the precipitate of coconut fibers need to be filtered and dried in the oven at 80 ºC for 24 hours.

- *LDPE*

Low Density Polyethylene (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 [8,11]. In this research, we use low density polyethylene as the matrix material (in the form of pallet with a density 0.92 gcm^{-1}) where the melting temperature were obtained at 180 ^oC. This compound consists of carbon, hydrogen, and some additives designed for general purpose applications, while the wax and the coconut coir is used for as a reinforcement material.

- *Process*

The formulation for LDPE, wax, and coconut coir is divided into four main compositions ratio as shown in Table 1, besides that, the two different methods used in term of mixing compositions shown in figure 1.

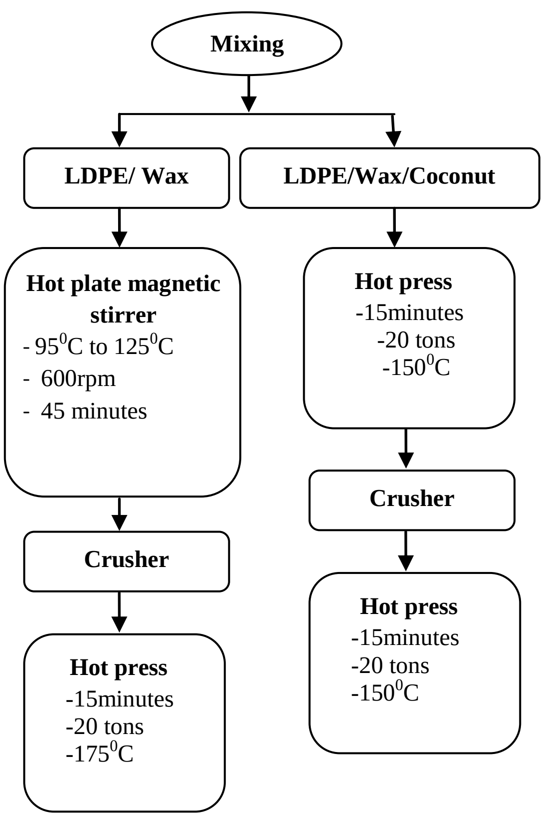

Figure 1: The flow chart of mixing process

Table 1
Compositions ratio of LDPE, wax & coconut coir

Compositions	LDPE (wt. %)	Wax (wt.%)	Coconut coir (wt. %)
1	90	8	2
2	90	6	4
3	90	4	6
4	90	2	8

The four 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. To observe the cracked of surface, the microscopic observation is carried out after the entire of three mechanical testing related to LDPE, wax, and coconut coir polymer carried out.

III. Results And Discussion

Tensile test

Figure 2 and 3 shows the effect of various composition ratios of LDPE/Wax on tensile strength modulus of LDPE/Wax/Coconut coir hybrid composites. The addition of 4 wt. % coconut coir brought down the tensile strength, increased at 6 wt. % coconut coir, and dropped at 8 %. For LDPE/Wax composites, the tensile strength increases with increment of wax percentages. However, when compared to the addition of 2 wt. % to 8 wt. % of coconut coir, they are still lower. For second composition, an addition of 4 wt. % coconut coir increase tensile strength about 3.9% as compared to LDPE/Wax composite. By loading of 6 wt. % of coconut coir on LDPE/Wax improve the maximum tensile strength about 8.6% compared to LDPE/wax composite.

Figure 2 show that all of the tensile strength of LDPE/Wax with coconut coir is better than LDPE/wax composite. Based on Figure 3, we can observe that both composites show the same trend. For LDPE/Wax first composition, loading of 2 % coconut coir increase 0.5 % stiffness of the hybrid composite. However, the composite with 4 % wax and 6 % coconut coir loading increase 0.3 % in tensile modulus.

As demonstrated in Figure 3 LDPE/ wax composite with coconut coir shows increment in tensile modulus.

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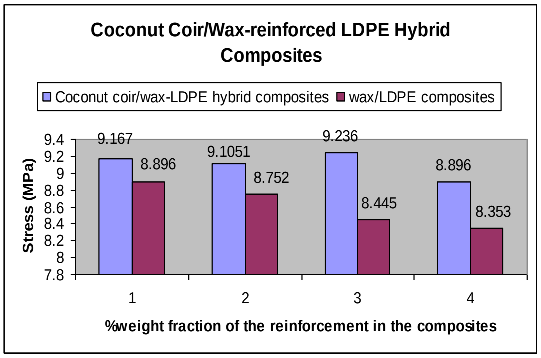

Figure 2: Chart of tensile strength against Percentage composition of LDPE

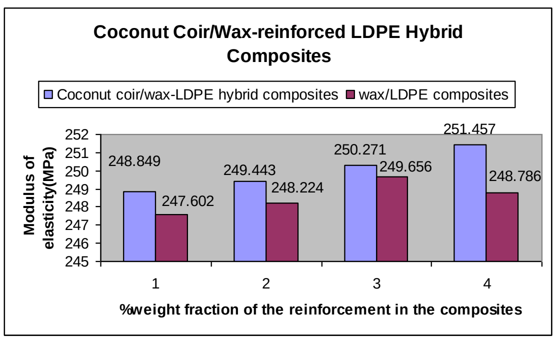

Figure 3: Chart of tension modulus against percentage composition of LDPE

Hardness test

Figure 4 demonstrates the effect of adding coconut coir on the hardness property of hybrid composite with LDPE/wax composite. The optimum hardness is obtained at 6 wt. % coconut coir, while LDPE/wax is 8 wt. % wax. It can be seen from the result obtained that hardness of hybrid composite with LDPE/wax/coconut coir is better than LDPE/wax composite. This result proved that reaction between coconut coir in LDPE/wax system increases the stiffness property of hybrid composite. An increase in overall fiber content into the hybrid composite with coconut coir fiber increases the hardness property of composite system. At only wax content, wax tends to penetrate into the matrix and thus decreases the hardness value compare to hybrid LDPE/wax/coconut coir. The highest hardness value of LDPE and wax composition is found at 8 wt. % wax, that is 50.9. Meanwhile, the highest value for hybrid composition 4 wt. % wax and 6 wt. % coconut coir is 61.2. The significant difference in the value shows that the percentage of hybrid compotation will increase the hardness of the material as the bonding between the molecules.

The addition of lower ratio of wax to LDPE/wax composition decrease hardness value. However, at 6 wt. % of LDPE/wax/coconut coir hybrid composite (90:4:6) gives high hardness value, which is 61.2 units, compared to LDPE/wax composite (90:4).

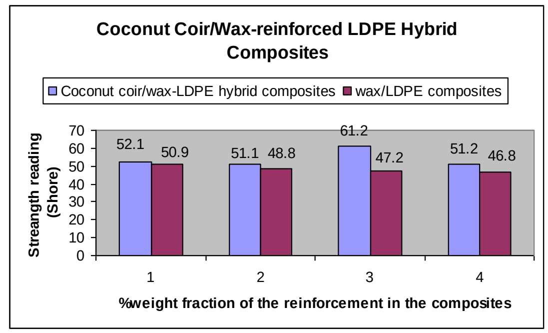

Figure 4: Graph of Durometer strength reading against percentage of composition of LDPE

Charpy impact test

Figure 5 show the effect of the addition of coconut coir against the impact strength. The LDPE/wax composites showed significantly higher impact strength as compared to hybrid composite at all percentages. Here, the toughness of composites is improved by the higher integration wax in LDPE matrix, which enhanced bonding between the polymers. These results are caused by unique combination of thermoplastic system contained in the matrix material. It's proven that the LDPE, wax, and coconut coir composition are lower than LDPE and wax. There are huge differences found between LDPE with 2 wt. % wax mixture compared to LDPE with 2 wt. % wax and 8 wt. % coconut coir mixture 58.03% of energy absorbed. The value increases consequently as the increment of coconut coir wt. % .

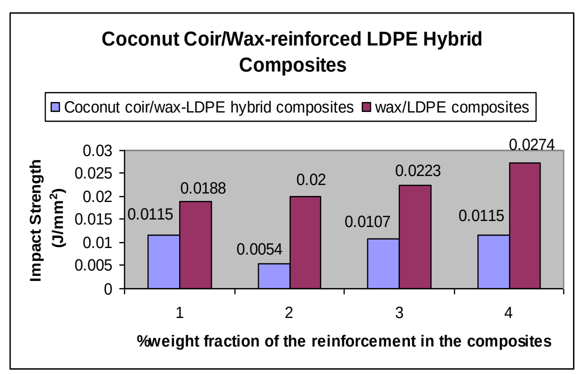

Figure 5: Graph of impact strength against LDPE percentage of composition

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Surface morphology of cracked specimens

The analysis towards surface morphology of the broken specimens carried out by using scanning electron microscope (SEM) 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. Figure 6 and 7 shows that different from other composition due to the coconut coir structure. From the images shown, most compositions of the composite mixed uniformly and have good bonding between them.

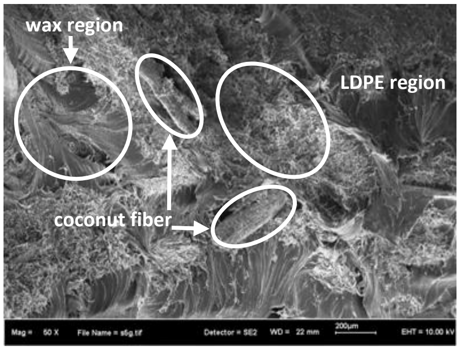

Figure 6: Mixture of 90 wt. % LDPE, 4 wt. % wax & 6 wt. % coconut coir

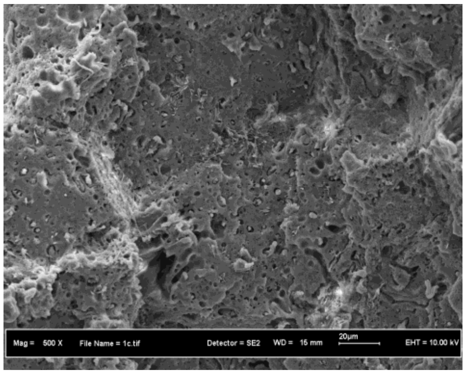

Figure 7: Mixture of 90 wt. % LDPE & 8 wt. % wax

IV. CONCLUSION

In this work, some of the mechanical properties of the LDPE/wax and the LDPE/wax/coconut coir (hybrid) composites have been described. The tensile and hardness properties of wax reinforced composites are observed where they are improved by the incorporation of coconut coir (showing a positive hybrid effect).

At the optimum loading of both coconut coir and wax (6/4), the strength seemed to be in increasing. Thus, coconut coir wax/LDPE hybrid composites resulted in having enhanced mechanical properties. The research also shows that by increasing of the strength against an object, using LDPE also to enable the increasing of income/ profit due to wax and coconut coir are less expensive and readily available [2,3].

V. ACKNOWLEDGMENT

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