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Analysis of Recycled HDPE Composite with OPEFB-Based Cellulose Fiber Reinforcement Characteristics for Casing Electronic Materials

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ABSTRACT
Composite is a product of advanced material innovation which has better mechanical properties than a single material. In addition, composites also have high impact strength so they can be applied as cassing electronic, construction of boat walls, car dashboards, and others. This innovative product can be made from high density polyethylene (HDPE) thermoplastic waste material with cellulose filler based empty palm oil fruit bunches (OPEFB). In this study, a comparison of composite modifications between HDPE and cellulose fibers was carried out. The ratio of matrix and filler composition used in this study is 90:10. The mixing of HDPE : Cellulose fibers using injection melt blending system and extruder technique. The composites are then made into specimens for tensile strenght and impact tests. The results of the tensile strenght and impact test HDPE : Cellulose fiber composite with ratio 90:10 is 27.000 Mpa and 0.261750877 Joules. Analysis results Scanning Electron Microscopy (SEM) on the morphology of the composite fracture, it is known that there is a bond between the matrix (HDPE) and filler (cellulose fiber). The results of this study indicate that composite of HDPE: cellulose fiber based OPEFB (90:10) has potential as a material for cassing electronic.

Keywords: *thermoplastic waste, cellulose fiber, OPEFB, composites, electronic casing, injection melt blending, extruder technique.*

1. Introduction

Composite is an innovation product that has better mechanical properties than a single material, this product can be applied in various daily needs. Composites can be made in a simple way, namely by heating and mixing plastics with compatibilizer materials (Zulnazri et al., 2014). This innovation product is the result of a study of several previous studies that have been carried out by the proposer, including the manufacture of composites from PET plastic waste using glass fiber filler in the form of a sandwich, then the manufacture of composites from HDPE, LDPE and PP plastic waste using OPEFB filler, lastly optimization of manufacture. composites from HDPE and PP plastic waste using OPEFB microfiber filler with an extruder process (Zulnazri et al., 2021). The three studies were conducted using different methods. The last study is a modification of the method of making and using different compatibilizers in order to obtain a better composite product (Zulnazri and Sulhatun, 2017). Composite products made from mixing HDPE plastic waste and OPEFB microfibers have also been patented with the number: P00201508086 (Zulnazri et al., 2016). Hence this product is very feasible to be used as an innovation that can be directly applied.

Composites that have been made previously for thermoplastic waste PP, LDPE and HDPE, with OPEFB filler are carried out through a blending process and press press with a hot press. The resulting composite product is very suitable to be used as a substitute for wood for furniture, even car interiors, electronic casings and elastic impact barriers (Zulnazri and Dewi, 2018; Zulnazri et al., 2020). This research is very much needed for the development of further innovations and product improvements so that these innovations can be used as products that can be applied directly as needed.

The problem faced in making this innovative product is that it is still constrained in printing composite products for electronic casing applications. For this reason, in this research activity, product improvements will be made using the injection melt blending method and the extruder technique combined with a composite mold for electronic board applications. This year an in-depth study was carried out to laboratory tests to determine the quality of composite products such as SEM test, impact test, tensile test.

2. Research Methods

2.1 HDPE plastic processing and Cellulose fiber processing as filler

Used HDPE plastics are sorted and washed thoroughly, then dried. Furthermore, the size is reduced by about 1-2 cm using a crusher. As for OPEFB, first cut into pieces using scissors so that the size is about 1-5 cm. The crude fiber is soaked in plain water for 24 hours, then dried in the sun to dry. The dried fiber is ground in mild grinding/pulverized to a micron size.

OPEFB fiber used as a filler is in the form of cellulose fiber which has gone through a delignification process. This process begins with boiling OPEFB measuring 1-5 cm with 5% NaOH at 70^{O}C for 30 minutes. Then filtered and washed with clean water until the brown color disappears. Next, it was bleached with sodium hypochlorite (2% NaOCl) at a temperature of 60-70^{O}C, then rinsed and dried.

2.2 Composite manufacturing

70 g of plastic matrix was mixed with 50 mL of 0.1% BPO initiator and stirred until well mixed. Then the hexane is evaporated. In a different container, 30 grams of cellulose-OPEFB fiber were mixed with 50 mL of 1% MAH compatibilizer, stirred until smooth. Then heated to evaporate the hexane (if necessary). These two ingredients are mixed so that the matrix becomes 100 gr : compatibilizer 100 ml (1 : 1). The second method: 70 g of plastic matrix mixed with 30 g of cellulose-OPEFB, then added with 50 ml of 0.1% BPO and 50 ml of 1% MAH, stirred until smooth. Then heated to evaporate the hexane (if necessary). The mixture is homogenized in melt blending/rollmil, to form irregular pellets (cross linking and compatible formation process). Then it is extruded to obtain a crystal composite of plastic ore.

3. Result and Discussion

[1] 3.1 HDPE-Cellulose Composite

The specimens from the composite molding of a mixture of HDPE and Cellulose with a ratio of the amount of HDPE and Cellulose as much as 90:10. This composite compared with another composites from previous research with variation HDPE : Cellulose is 70:30 and 80:20.

3.2 HDPE-Cellulose Tensile Test Results

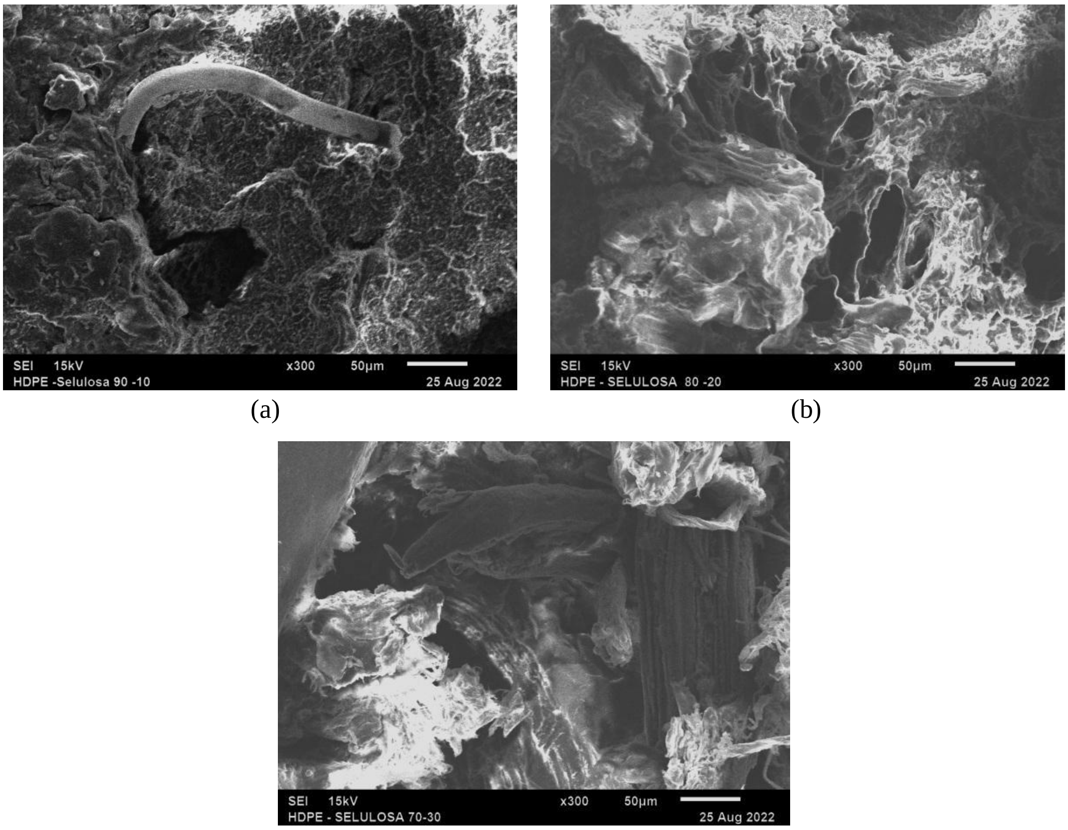
Table 1. HDPE-Cellulose Tensile Test Results

Name	Max_Stress	Max_Force	Break_Force	Break_Disp.
Parameters	Tensile Strength	Maximum Load	Stress at Break	Nominal Strain at Break
Unit	MPa	N	Mpa	mm
HDPE-Selulosa 90:10	27.000	274.000	27.000	0.036
HDPE-Selulosa 80:20	26.000	258.000	26.000	0.030
HDPE-Selulosa 70:30	32.000	316.000	32.000	0.036

Based on Tabel 1 it can be seen that composite mixture of HDPE : Cellulose fiber (90 : 10) has tensile strenght value is 27.000 MPa.

3.3 SEM of HDPE-Cellulose Composite

The morphology of the composite were analyzed by scanning electron micrographs (SEM). Reaction time, reaction temperature, ratio of raw materials to acids and the nature of the raw materials greatly determine the yield and particle size distribution (Zulnazri, 2017). Figure 1 is the result of SEM analysis showing the fracture morphology of the composite from a mixture of HDPE - Cellulose with a scale of 50µm and a magnification of 300 times.



(a) (b)

(c)

Figure 1 SEM analysis results of HDPE-Cellulose composites (a) 90:10, (b) 80:20, (c) 70:30

SEM analysis composite from Figure 1 as a whole shows a brittle fracture form, due to the high applied tensile force causing the composite to break irregularly, this shows that the composite has good compatibility between the matrix and the fiber.

3.4 HDPE-Cellulose Impact Test Results

Impact test analysis is one of the tests of composite materials to determine the ability of a material to accept impact loads which measure the amount of energy required to break a material specimen. The results of the impact test on the 3 types of composites can be seen in Table 2.

Table 2. HDPE-Cellulose Impact Test Results

Composition	Cross-sectional area (A)	Degree		R (meter)	G (Joule)	Impact (W) (Joule)	Tenacity (W/A) (Joule/mm²)
		α	β				
HDPE : Cellulose 90:10	80	160	154	0.256	25	0.261750877	0.003271886
HDPE : Cellulose 80:20	80	160	155	0.256	25	0.213662936	0.002670787
HDPE : Cellulose 70:30	80	160	152	0.256	25	0.363168179	0.004539602

3.4 HDPE-Cellulose FTIR Test Results

The characteristic feature of the FT-IR spectrum of cellulose is that it displays two main absorption areas, namely in the high wave number and low wave number areas. From the test results of cellulose from empty palm oil bunches, it was found that the high wave number was 2800-3300 cm^{-1} and the low wave number was 500-1400 cm^{-1}. The spectrum shows a broad absorption peak located at 2800-4000 cm^{-1} which is a stretch of the -OH group. The absorption peak in the area 2890-2900 cm^{-1} is related to the $-CH_2$

group, this is in accordance with a study conducted by Jahan et al., (2011). The absorption peak in the 2862 cm^{-1} region is an overlapping of the $-CH_2$ band.

The functional group analysis of the HDPE and cellulose mixed composite can be seen in Figure 2:

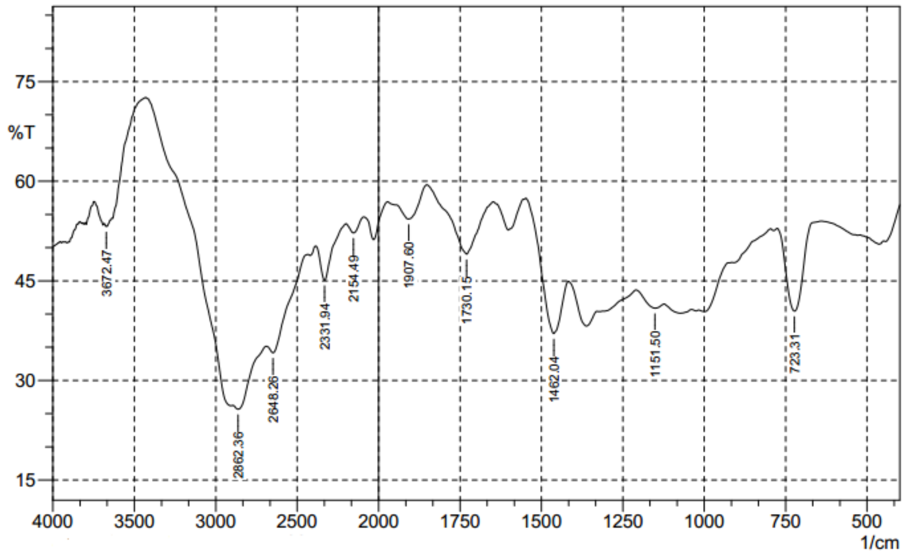


Figure 2 FTIR Spectrum HDPE-Cellulose

4. CONCLUSION

The process of mixing HDPE with cellulose is carried out using the melt blending method. Cellulose was obtained from the delignification process of OPEFB crude fiber using 5% NaOH at 70^{O}C for 30 minutes. The results of the tensile test which showed tensile strength value was 27.000 Mpa for HDPE: Cellulose fiber (90 : 10). The results of Scanning Electron Microscopy (SEM) showed the fracture morphology of the composite mixed with HDPE and Cellulose. Impact test HDPE: Cellulose fiber composite results with ratio 90:10 is 0.261750877 Joules. The FT-IR test showed the presence of deformation from C-H and pyranose C-O-C vibrations which are typical of cellulose at wave numbers 1070.49 & 1151.50 cm^{-1} and O-H intermolecular bending in cellulose at wave numbers 3672.47 cm^{-1}. The results of this study indicate that composite of HDPE: cellulose fiber based OPEFB (90:10) has potential as a material for cassing electronic.

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