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RATING OF SOME PHYSICAL PROPERTIES OF POLYETHYLENE/IROKO WOOD DUST COMPOSITE

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ABSTRACT

There is a growing need for construction material resources, as well as the concern for maintaining a safe environment for durable development, it is necessary that more materials that are environmentally friendly should be developed. Water absorption, morphology, flammability and hardness test of Polyethylene/Iroko wood dust composite was evaluated. High water absorption was observed in composite made from virgin high density polyethylene film, which varied from 43.2 to 98.2% after 2 h and 75.7 to 172.4% after 24 h water immersion, whereas the composite made from waste high density polyethylene film varied from 42.5 to 90.9% and 69 to 143.6% after 2 h and 24 h water immersion respectively. Low water absorption was observed in composite made from waste high density polyethylene film. Flammability results showed that ignition time and flame propagation time increased with increasing fibre content for both composite types. At constant polyethylene. The hardness decreases as the fibre increases from (61.3 to 20 MPa) for virgin high density polyethylene film base composite. For waste high density polyethylene film base composite, the waste high density polyethylene composite is harder than the virgin high density polyethylene composite. Scanning electron microscope shows that most of the fibres and the matrix do not give apparent signs of fibres being pullout, indicating an improved interface bond for the virgin high density polyethylene/Iroko composite.

Keywords: Polyethylene, Iroko Wood, Composites, Density

INTRODUCTION

Wood plastic composite has emerged as an issue of great importance in recent decades (Eva *at al.,* 2013). Despite the substantial efforts devoted to this matter, it should be considered that the efficient large-scale implementation of plastic recycling represents a goal which is still far from being fully achieved by the recycling industry (Adhikary *et al.,* 2008). The major obstacle arises from the low compatibility of different components in plastic recycling.

Currently the amount of garbage or waste is increasing day by day as the world's population increases. If we see closely, most of the wastes are from the things that we used daily such as plastic and paper. Due to the increasing amount of mankind in the world, more products have to be manufactured to cater the needs of every human being (Bouafif *et al.,* 2009). These cause natural resources such as wood and petroleum to deplete fast (Dominkovics *et al.,* 2007). Wood has been used as reinforcing filler in thermoset polymer for decades, however, its use in thermoplastics is a relatively new spurred by improvement in processing technology and development of coupling agents (Dominkovics *et al.,* 2007). Use of wood as the filler in WPCs

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has advantages such as low-cost, renewable, biodegradability, low specific gravity, and low abrasion to equipment as compared with inorganic fillers (e.g. glass fibers and clay).

This work covers the preparation and testing of polyethylene and Iroko hard wood dust composite. The properties of the composite materials were tested, i.e. the water absorption, hardness test, morphological feature and flammability. The product is expected to compete favorably in the local and international market.

MATERIALS AND METHODS

Preparation of Wood plastic composite (ASTM D618)

Wood dust was dried in an oven at 100 °C for 24 h to remove moisture and cooled wood dust ground to give fine powdered particles after sieving for easy dispersion in the formulation (Dass *et al.*, 2016). For all the formulations prepared, toluene was measured into a conical flask and was mixed with a certain gram of the resin. The mixture was prepared at temperature of 135^0C in an oil bath till the resin dissolved totally in the solvent. Saw dust was measured and added to the solvent-resin mixture and stirred continuously for at least five (5) min at same temperature the mixture was then cast in an aluminum mold with 3 m thickness, 7 m width and 10 m length. The composite was made conditioned at a temperature of 23±2°C and relative humidity (RH) of 50±5% for at least 40 h according to ASTM D618-99.

Water absorption (ASTM D 570)

Water absorption of the composites was determined after 2 h and 24 h by immersion in distilled water at room temperature, 24°C. Five specimens of each formulation were dried in an oven for 24 h. The dried specimens were weighed with a precision of 0.001 g. All specimens were immersed in distilled water. At the end of the immersion periods, the specimens were removed from the distilled water, the surface water was wiped off using tissue, and wet weight values were determined. Water absorption percent was calculated using the following formula (Gwon *et al.*, 2010; Kamal, 2009).

$M\ (\%) = (m_t - m_o)/m_o \times 100,$

Where m_o and m_t denote the oven-dry weight and weight after time t, respectively.

Flammability Test (ASTM D635)

A 60 mm mark was measured and marked out on each of the specimen. The specimen was then clamped horizontal in a retort stand with the marked 60 mm distance protruding out of the clamp. The free end of the sample was ignited and the time taken for the sample to ignite was recorded as the ignition (I_t). The sample was allowed to burn to 60 mm mark (D_p). The relative rates of burning for the different samples were determined using the expression (Ewulonu, 2009) stated below:

Flame propagation rate (mm/s) = D_p (mm)/P_t(sec)- I_t(sec)

Where, D_p = Propagation distance measured in mm, P_t = Flame propagation time measured in seconds, I_t = Ignition time measured in seconds.

Hardness Test (ASTM D-2240)

The hardness test was carried out using Modified Meyer hardness tester. The hardness for the samples was determined using the expression stated bellow.

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$$BHN = \frac{F}{\frac{\pi}{2}(D - \sqrt{D^2 - D_i})}$$

Where, F = The imposed load, D = Diameter of the indenter, D_i = Diameter of the indentation

Scanning Electron Microscopy (SEM) ASTM E9862

A morphology study was carried out using scanning electron microscopy (SEM) to evaluate the fractured surface of samples. The changes in morphology are important to predict fiber interaction with the matrix in composites (Moh'd and Sahrim, 2011).

RESULTS AND DISCUSSION

3.1 Water Absorption of the High-Density Polyethylene and Iroko Wood Particles Composite

Figure 1 shows the water absorption of virgin and waste high density polyethylene/Iroko wood dust particle at constant polyethylene film composite. High water absorption was observed in composite made from virgin high density polyethylene film which varied from 43.2 to 98.2% after 2 h and 75.7 to 172.4% after 24 h water immersion whereas the composite made from waste high density polyethylene film varied from 42.5 to 90.9% and 69 to 143.6% after 2 h and 24 h water immersion respectively. Composite made from waste high density polyethylene film decreases from 34.5 to 3.6% and 59.8 to 4.6% after 2 h and 24 h water immersion (Dass *et al.*, 2016).

Figure 2 shows the water absorption of virgin and waste high density polyethylene/Iroko wood dust particle composite at constant sawdust. Low water absorption was observed in composite made from waste high density polyethylene film which decreased from 43.2 to 5.3% after 2 h and 75.7 to 6.9% after 24 h water immersion whereas the composite made from virgin high density polyethylene film decreased from 42.5 to 4.4% and 69.0 to 6.9% after 2 h and 24 h water immersion respectively. Dass *et al.*, 2016, shows that Low water absorption was observed in composite made from virgin high density polyethylene film which decreased from 35.7 to 4% after 2 h and 65.5 to 7.3% after 24 h water immersion. This result is in consistency with the results.

The impact of wood to plastic ratio on the water absorption can be explained by the differences in water absorption between wood and plastic. Water absorption in composites is mainly due to the presence of lumens, fine pores and hydrogen bonding sites in the wood flour, the gaps and flaws at the interfaces, and the micro-cracks in the matrix formed during the compounding process (Stokke and Gardner, 2003).

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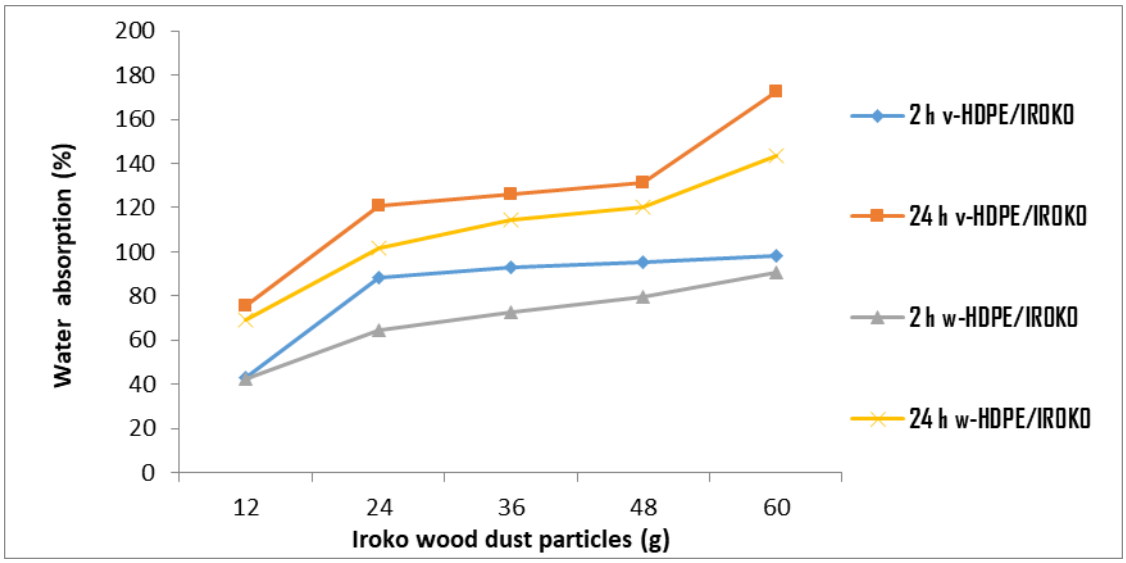

Figure 1: Effect of filler content on Water absorption of Iroko wood particle with virgin and waste high density polyethylene

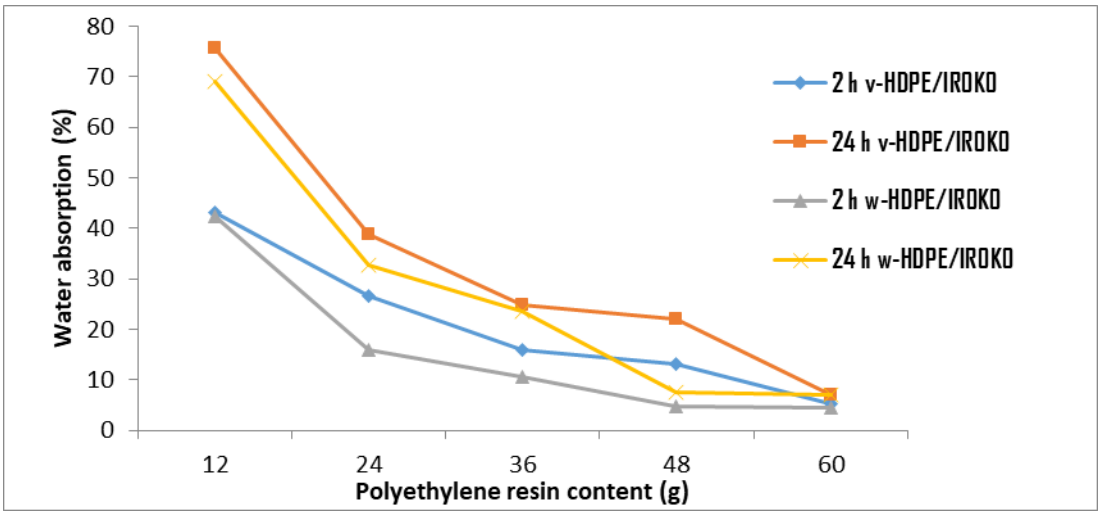

Figure 2: Effect of resin content on water absorption of Iroko wood particle with virgin and waste high density polyethylene film.

Flammability Test

Figure 3 gives the flammability of virgin and waste high density polyethylene/Iroko wood dust particle composite at constant polyethylene film. Ignition time decreased as the wood dust particle increases which make the flame propagation rate of the composite to increase from (0.65 to 0.22 mm/s) for the virgin high density polyethylene composite and (0.73 to 0.33 mm/s) for waste high density polyethylene composite. Dass *et al.*, 2016. Flammability test shows that ignition time increased as the polymer resin content increases (0.65 to 0.09mm/s) for the virgin high density polyethylene composite and (0.8 to 20.8 MPa) for waste high density polyethylene film base composite.

Figure 4 shows the flammability of virgin and waste high density polyethylene

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film/Iroko wood dust particle composition at constant sawdust. Ignition time increased as the polymer resin content increased which make the flame propagation rate of the composite to decrease from (0.65 to 0.09mm/s) for the virgin high density polyethylene composite and (0.73 to 0.15mm/s) for waste high density polyethylene composite. Gradual reduction in flammability of the composite was observed as the Doka wood particles and high polyethylene films increases (Dass *et al.,* 2016).

These pores are interconnected with each other and develop a network of void spaces. This network allows oxygen to pass through these pores and enhance ignition. Materials that contain a higher content of cellulose fibres generally have a greater density and resistance to oxidation. Therefore, if the porosity of the composite is reduced, then the oxidation is restricted (Khosravian, 2010). Increasing the oxygen index results in more oxygen required for burning the sample, making the ignition process more difficult. As the ratio of wood flour to polymer matrix increases the oxygen index increases which was in accordance with existing literature (Mohammad *et al*., 2015)

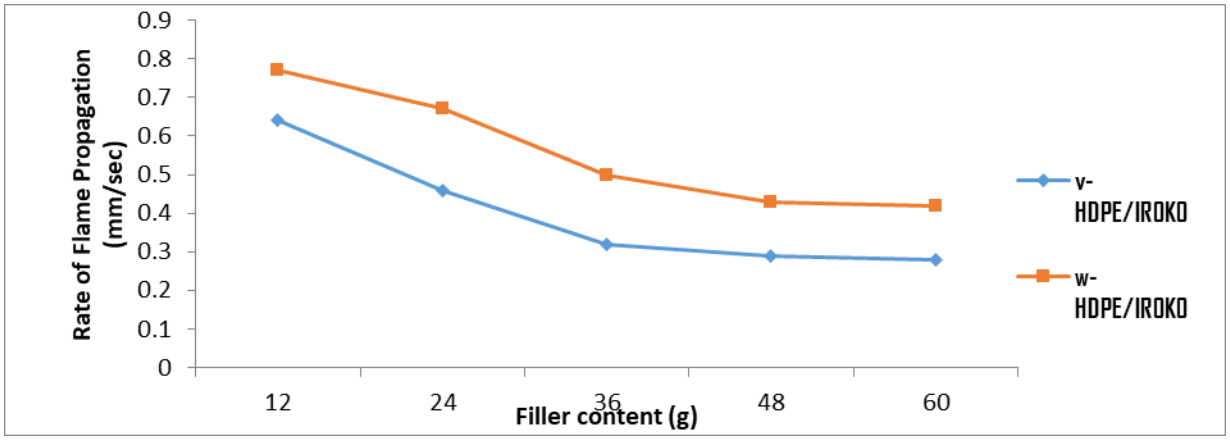

Figure 3: Effect of filler content on rate of flame propagation of Iroko wood particle with virgin and waste high density polyethylene film-based composites at constant polyethylene.

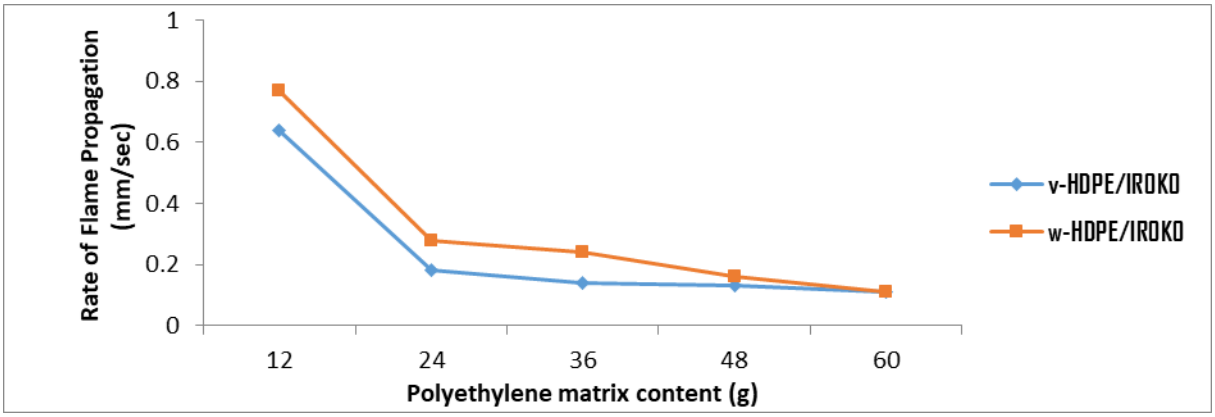

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Figure 4: Effect of resin content on rate of flame propagation of Iroko wood particle with virgin and waste high density polyethylene film-based composites at constant sawdust. polyethylene composite.

Hardness Test

Figure 5 and figure 6 show the hardness of virgin and waste high density polyethylene/Iroko wood particle dust composite at constant polyethylene and at constant sawdust respectively. At constant polyethylene the hardness decreases as the fibre increases from (61.3 to 20 MPa) for virgin high density polyethylene film base composite and (81.6 to 28 MPa) for waste high density polyethylene film base composite the waste high density polyethylene composite is harder than the Virgin high density polyethylene composite. While at constant sawdust hardness increases as the polymer resin increases from (61.3 to 363.6 MPa) for virgin high density polyethylene and (81.6 to 507.8 MPa) it also recorded high hardness in waste high density polyethylene composite than in virgin high density. Dass *et al.,* 2021 determine the hardness and results in At constant polyethylene the hardness decreased as the fibre increased for virgin high density polyethylene film base composite and for waste high density polyethylene film base composite the virgin high density polyethylene composite is harder than the waste high density polyethylene composite. While at constant sawdust hardness increases as the polymer resin increases from (81.6 to 445.8 MPa) for virgin high density polyethylene film and (68.8 to 363.6 MPa) it also recorded high hardness in virgin high density polyethylene composite than in waste high density polyethylene composite.

In general indentation values increased with increasing fibre content whereas they decreased with increasing polymer resin content. The increasing indentation value (i.e., depth) with increasing fibre loading could be as a result of the fibre/matrix adhesion. Since indentation values suggest the depth of impact the material could withstand before deformation, this could mean that the load sharing between matrix and fibre help reduce the load on the matrix, consequently increasing the indentation values. Hardness values which showed the behaviour of the material under immediate impact and not gradual loading decreased with increasing fibre content. Decrease in Shore hardness value with increasing fibre content has also been reported by Khairaih and Khairhul (2006), when working on polyurethane and empty fruit bunch blend composites. They alluded the decrease to the inability of the matrix to encapsulate the fibre strands, even though good interfacial bonds might exist between fibre and matrix. Anap (2008), also reported decrease in Shore hardness value with increasing fibre loading when high density polyethylene was reinforced with wood fibres.

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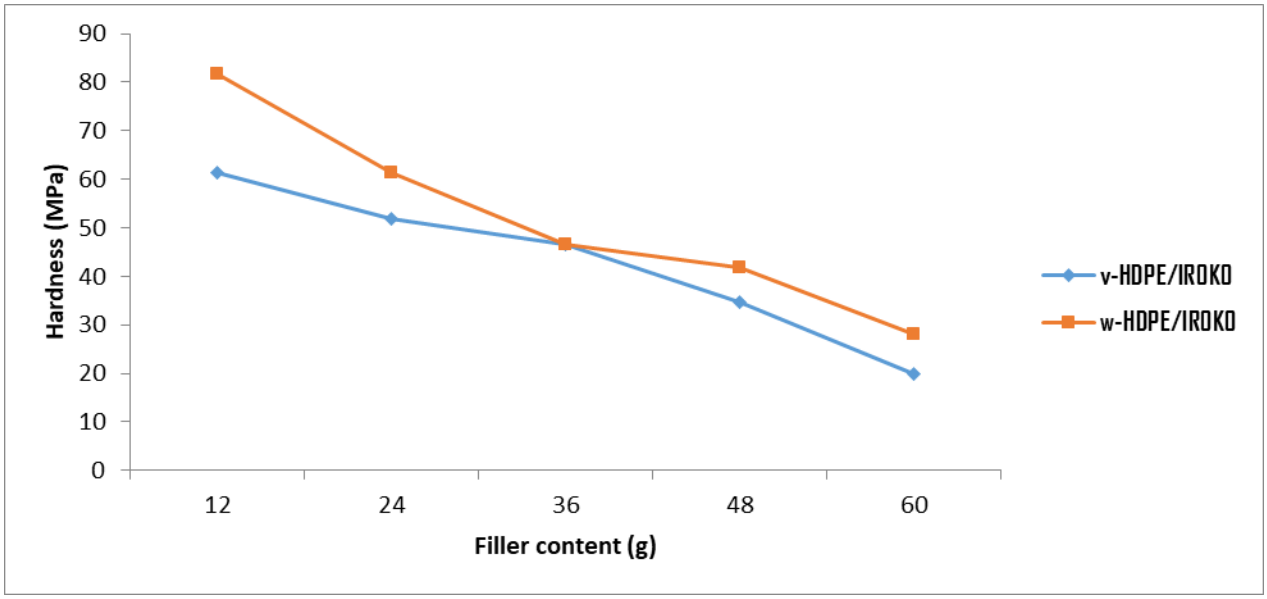

Figure 5: Effect of filler content on hardness of Iroko wood particle with virgin and waste high density polyethylene film-based composites at constant polyethylene.

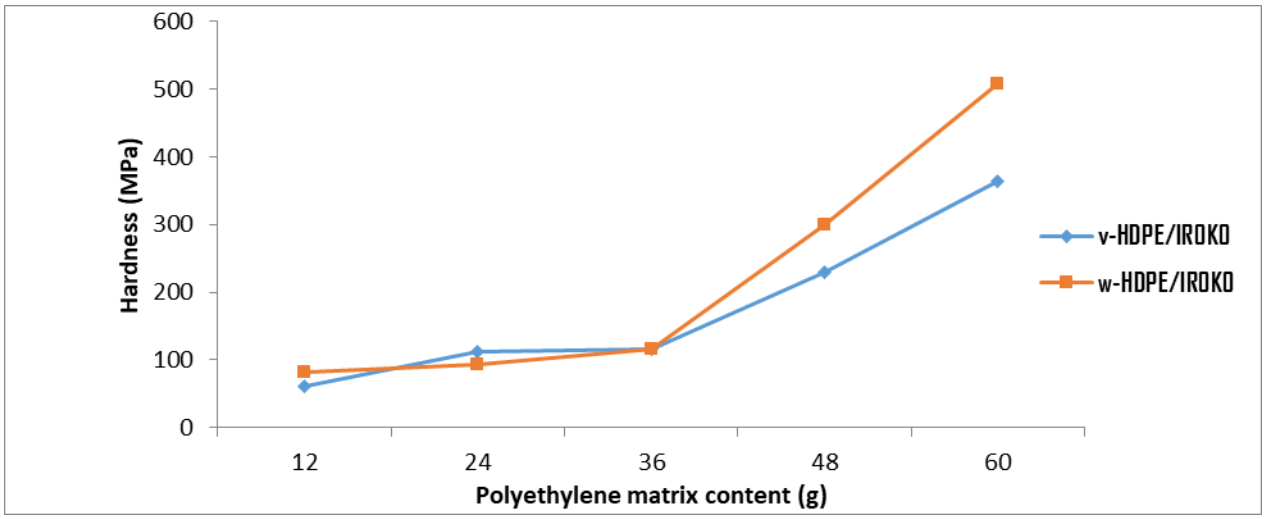

Figure 6: Effect of resin content on hardness of Iroko wood particle with virgin and waste high density polyethylene film-based composites at constant sawdust

Scanning Electron Microscope

Figs. 7 (a) shows that most of the fibres and the matrix didn't show apparent signs of fibres being pullout, indicating an improved interface bond for the virgin high density polyethylene/Iroko sample, in contrast (Figure 7 (b)) made of waste high density polyethylene/ Iroko composite samples failed in more ductile manner, exhibiting cavity formation and fibres being pulled out. waste high density polyethylene /Iroko composite (Fig. 8 (d)) is uniform as compared to virgin high density polyethylene /Iroko composite

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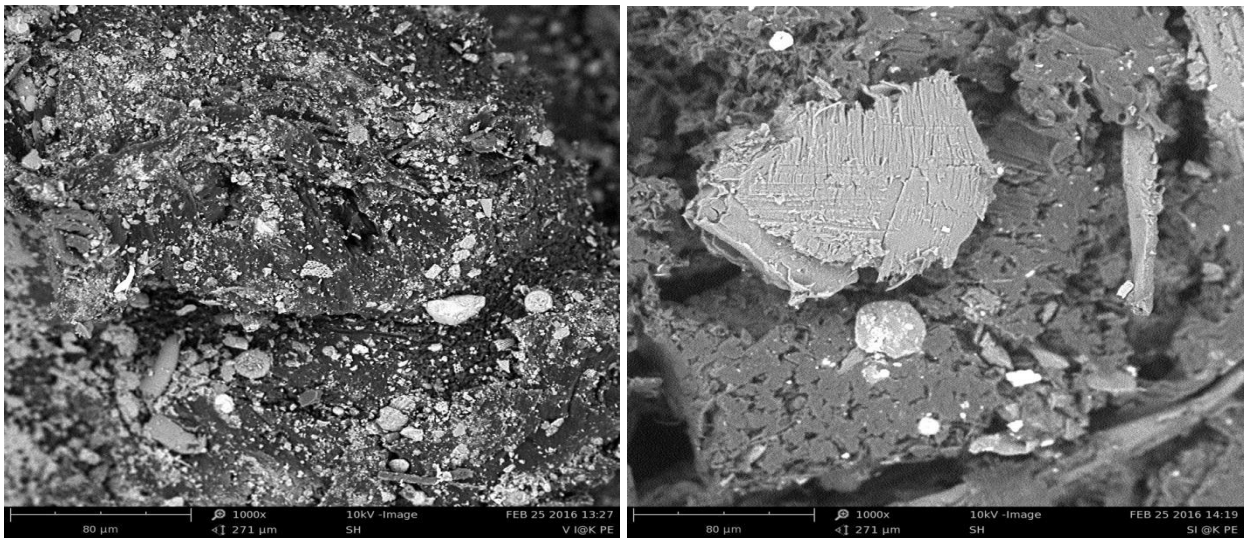
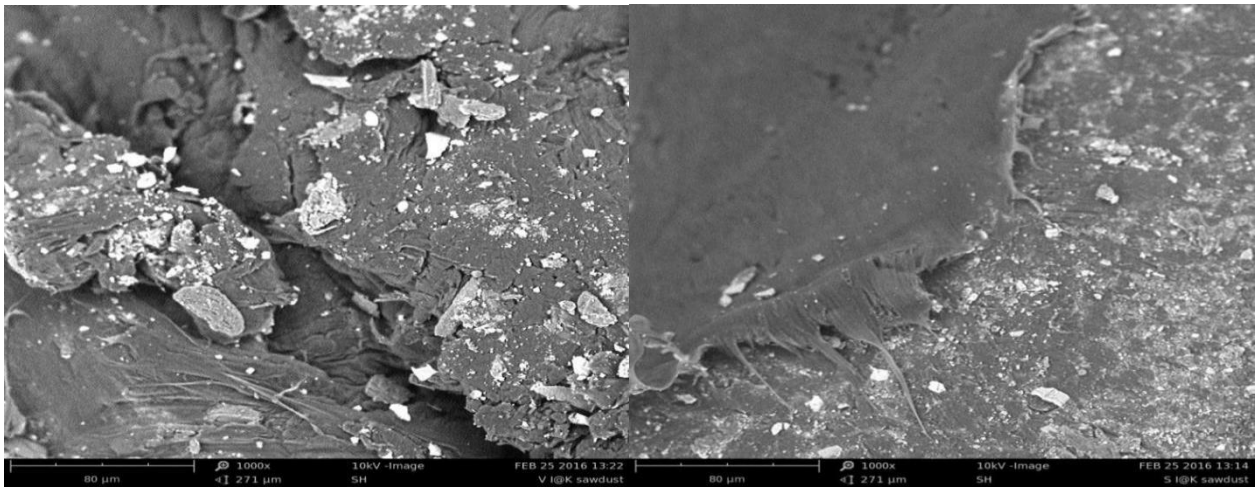
(Fig. 8 (c)). This may be due to the different grade of plastic and the compatibility of the fibre with the waste high density polyethylene

Film Dass *et al.*, 2016, states that it is clearly observed that there were distinct cluster and gaps between polymer matrix and wood. The patterns from wood fibres that were so weakly bonded to the matrix had been released from the matrix. The failure surface was undulated with clear wood flour surfaces with visible trachaids and lumen. This shows weaker part through the wood-wood interface and weakest polymer matrix. This suggests that the interface between the wood and HDPE matrix was weaker due to the poor dispersion and wettability between the two phases.



(a) (b)

Figure 7: SEM images (×1000) of (a) vHDPE 12 g / Iroko 24 g, composite (b) wHDPE 12 g / Iroko 24 g composite.



(c) (d)

Figure 8: SEM images (×1000) of (c) vHDPE 12 g and Iroko 24 g composite. (d) wHDPE 24 g / Iroko 12 g composite.

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CONCLUSION

Rating of some physical properties of Polyethylene/Iroko wood dust composite, showed that ignition time increase as the wood dust particle increased for the virgin high density polyethylene composite and for waste high density polyethylene composite. Flammability test shows that ignition time increased as the polymer resin content increases for the virgin high density polyethylene composite and for waste high density polyethylene film base composite SEM show pronounced deformation of the polymer matrix and significant reduction in fiber pull-out, indicating the compatibilizer likely affects interface, reducing interfacial tension and improving adhesion.

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