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THE USE OF FLAME OF FOREST POD FLOUR IN HIGH DENSITY POLYETHYLENE COMPOSITE

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Abstract: Polymer composites are known to have improved outstanding properties compared to pure materials. Polymeric material based composite was compounded from flame of forest pod flour (FFPF) and high density polyethylene (HDPE). The manufactured flame of forest pod flour-high density polyethylene (FFPF-HDPE) composite was studied based on the influence of particle size and content of FFPF on its mechanical properties. The pure HDPE, FFPF and FFPF-HDPE composite was examined using Fourier Transform Infrared (FTIR) to know the functional group/bonds characteristics present. The results obtained from this work shows that the particle size and mass content of FFPF influenced the properties of the FFPF-HDPE composite. With this outcome, this composite can be applied for domestic purposes based on the limit of its properties.
Keywords: FFPF, FFPF-HDPE, mechanical properties, FTIR

INTRODUCTON

Studies have shown that, different natural local fibres which have been neglected over time, are becoming perfect substitute for inorganic fillers for use as reinforcement in composite [1], [2], [3], [4]. Bearing this in mind, it seems most Africa countries are not doing much in following the western world in the drive of converting local resources in their domain into source of wealth. Moreover, the availability of organic fibers in nature will help to reduce the cost of composite production as they also help in complementing the properties of polymer composite [5], [6], [7], [8]. This means that the search for suitable fibers is pivotal to upgrading the performance of fiber-plastic composites which is one of the qualities of a good researcher in solving societal problems. Ultimately, qualities of fiber to be use as an additive are function of internal characterization of the filler [9]. Presently, there are thousands of low cost fibres/fillers found in nature that are wasting away as composite manure and being burnt as a means of fuel for heating and cooking purposes. The burning process discharges emission and pollutants to the environment. It is on this note that the world health organization (WHO) and other environmental agencies are looking for ways to curb this menace. There is much emphasis to utilize these organic fillers as a constituent in polymer composite to create wealth and to reduce environmental challenges. Recently, some of the natural fillers have been explored in polymeric based composites to produce light product at lowest cost which displays comparable specific strength and minimal density than metallic components for domestic and industrial products [10], [11], [12], [13]. A good Plastic composite is a function of filler/fibre composition, aspect ratio of the filler, polymer matrix, chemical modification and the process technology employed [14], [15]. Therefore, particle size distribution and mass content of lignocellulose as presented in this work are the major parameters influencing plastic based composites. Lately, some scholars have carried out tremendous works on how these factors determine the final properties of composite using other natural fibres. Some of them include oil palm [16], walnut shell [17], saw-dust [18], coconut shell [19], corn cob flour [20], raphia palm [21], and peanut shell [22] have been researched into by these researchers in relation to plastic composites. Interestingly, flame of forest plant is found in some residential areas and in the forest as well, but its prospect and potentials has been ignored over the years. It is on this basis that the use of flame of forest pod flour (FFPF) as reinforcement in polymer based composite is researched into as a novel initiative that has not been worked on to the best of my knowledge.

MATERIALS AND METHODS

— FFPF PREPARATION AND SOURCING

The flame of forest pod (FFP) was obtained at Park Avenue G.R.A Enugu. The FFP was dried for 18 hours in the sun. The FFP was subjected to grinding and sieving, respectively. The FFPF was sieved into a particle size distribution of 425 μm, 850 μm and 2000 μm.

— PURCHASING OF HDPE

HDPE was bought in Owada, Onitsha Anambra State.

— COMPOSITE PREPARATION AND TESTING

The HDPE was reinforced by FFPF at 10, 20, 30, 40 percentage by weight and compounded through injection molding machine (HUICHON/5SON10/500×1000 model no.6241 1990/6) at the above three variation particle sizes. The composites manufactured were tested by the aid of universal tensile (BSS1610 model no. 8889) and simple Charpy impact equipments (LOS LOSENHAUSENWERK DUSSELDORFER MASCHINENBAU AG. DUSSELLDORF, model no.17562/1963). The properties determined were ultimate tensile strength, elongation, Young's modulus, Brinell's hardness and impact strength. These mechanical properties were evaluated based ASTM procedure [23].

— FOURIER INFRA RED TEST (FTIR)

The analysis for FFPF, HDPE and FFPF-HDPE composite was determined using Shimazdu FTIR machine (model no 8400S).

RESULTS AND DISCUSSION

— FTIR CHARACTERIZATION

The FTIR of raw HDPE, FFPF and FFPF-HDPE composite were captured in Figure 1, Figure 2, Figure 3, respectively.

There are many display of OH group found in 3878.73-3362.51 cm^{-1}, 3868.08-3390.34 cm^{-1}, 3616.84-3362.64 cm^{-1}, for Figure 1, Figure 2 and Figure 3, respectively. For the HDPE, FFPF and FFPF-HDPE composite, the transmittance took a shift from 9.589 to 10.38 %, 8.403 to 3.519% and 5.579 to 5.506%, respectively. This is the conditions of the peaks when HDPE and FFPF are in their raw state, and both combinations also leads to the reduction of intensity during the formation of composite as shown in the Figure 1-3.

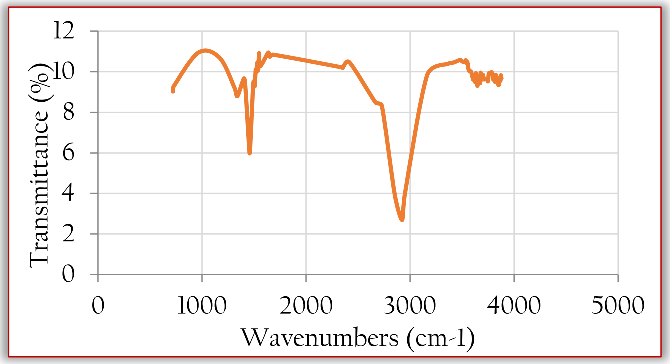


Figure 1. FTIR FOR HDPE

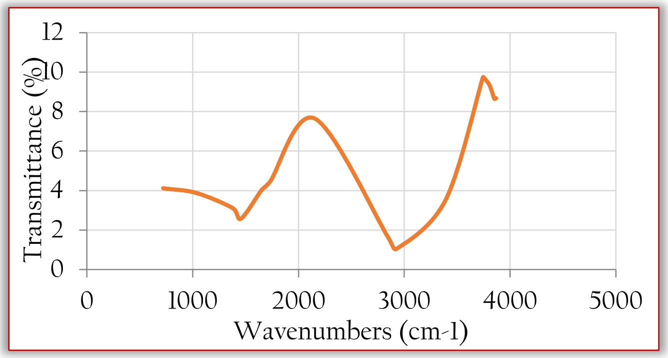


Figure 2. FTIR FOR FFPF

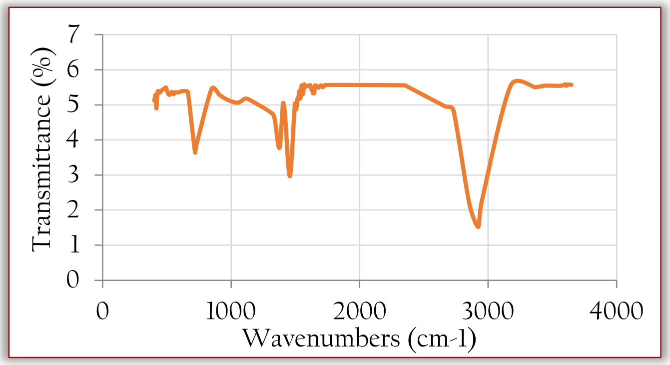


Figure 3. FTIR FOR FFPF-HDPE COMPOSITE

There are crests of the wavelength from 2923.32-2663.97 cm^{-1} that distribute COOH active group for HDPE, FFPF and the composite. The peaks from 2415.79-2145.79 represented P-OH stretching compounds as shown in Figure 1-3.

The Figure 2-3 gives the attribute of C=O stretching aliphatic which transmits from the wavelength of 1732.46 to 1732.86 cm^{-1} at 4.458 to 5.567% during the inclusion of FFPF into HDPE for production of FFPF-HDPE but invisible in Figure 1. The availability for C=O stretching aromatic is discovered at peak of 1698.26-1682.82 cm^{-1} from 10.833 to 5.496% in Figure 1 to Figure 3. The NH_2 bending was domiciled in FFPF to FFPF-HDPE at 1651.63 to 1622.34 cm^{-1} with a displacement in the intensity of transmission, this is totally unavailable in the raw HDPE. The features of the crests dormant at 1645.83-1607.74cm^{-1} formed C=H stretching found in the Figure 1-3. The influence of C-Cl radicals was dominating in the peaks of 592.07-402.3 cm^{-1} in Figure 3 was completely absence in Figure 2 and 1.

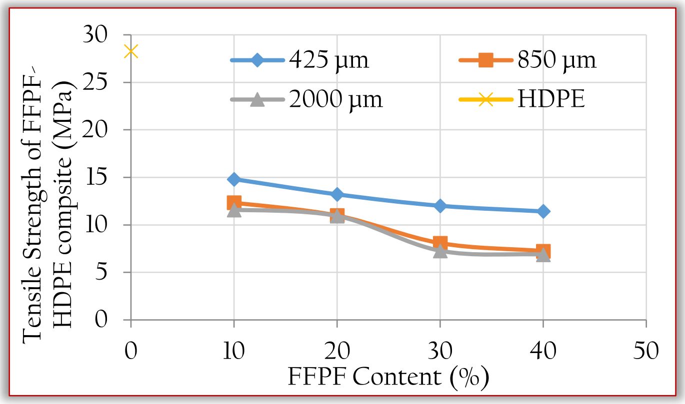
— MECHANICAL CHARACTERIZATION OF THE COMPOSITE

Figure 4 (a) shows a graphical description of the impact of the FFPF content and particle size distribution on the tensile strength of FFPF-HDPE composite. The tensile strength of FFPF-HDPE depreciated from the crude HDPE when the FFPF content is added. A similar situation occurred when the FFPF particle size is increased. This reason may be due to the influencing increasing large particle size of FFPF resulting to non-uniform distribution of FFPF and HDPE phase.

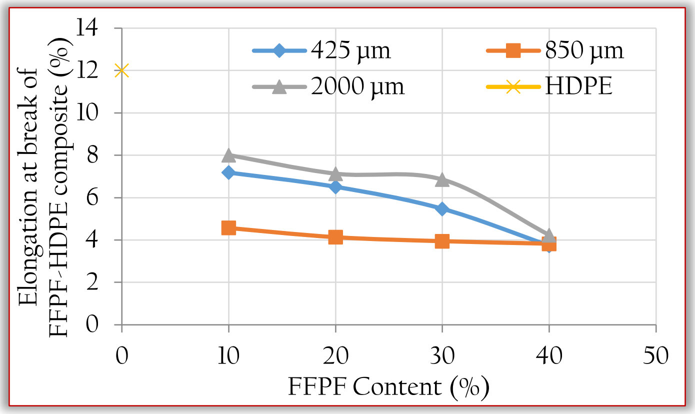
Similar report was presented by the following researchers [2], [9], [11]. The elongation of FFPF-HDPE composite variation with FFPF content was also highlighted in Figure 4(b). The incorporation of FFPF content in HDPE thoroughly reduced elongation of the crude polymer. The elongation at breaks of FFPF-HDPE composite was lowest at 2000 μm, followed by 850 μm and 450 μm. This was firmly attributed to bigger size of FFPF particles which will generate more spaces at the union of FFPF and HDPE, thereby reducing the ductility of the composite. This trend was also previously reported by these researches in their works [2], [9], [24].

Figure 4(c) expresses the graphical changes between the tensile modulus of FFPF-HDPE composite and FFPF content. The modulus of elasticity of FFPF-HDPE composite rises as the FFPF content was infused in HDPE. This occurrence is due to the amalgamation of FFPF content into HDPE, causing the FFPF–HDPE composite ductile ability to cutback, leading to the enhancement of the stiffness nature of the composite. Nevertheless, the utmost young's modulus was attained at FFPF size of 850 μm. These were reported as follows [2], [9], [18].

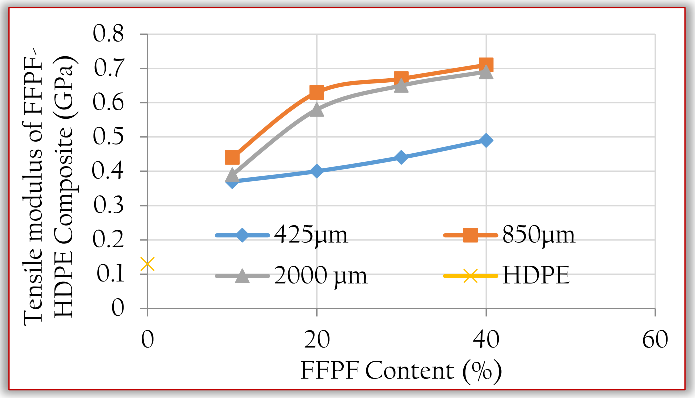
Figure 4(d) describes the impact strength of FFPF-HDPE composite versus the FFPF content. The impact strength of FFPF-HDPE composite absolutely increased as the FFPF content was continuously added in the HDPE matrix with the lessening of the size of FFPF. This attribution is in association of adding FFPF content into polymeric substances, triggering more energy to formalize cracks promulgation at lower sizes of FFPF. Though, the most Impact strength occurred at minimal size of FFPF. These were related to the trend as reported by previous studies [16], [18], [25], [26]. Figure 4 (e) features Brinell hardness number of FFPF-HDPE composite as a function of FFPF content. It was obviously observed that the insertion of FFPF content in the HDPE generally swells Brinell hardness number of FFPF-HDPE composite by 1107 %, 718 % and 292% as the size of FFPF increases from 425-2000 µm. Conversely, reducing FFPF size favoured the Brinell hardness of FFPF-HDPE composite. The motivation for this trend of results is absolutely due to introduction of FFPF content into HDPE matrix completely resisting the possibility of indentation. Previously, these researchers also discussed this pattern of report [24], [27].



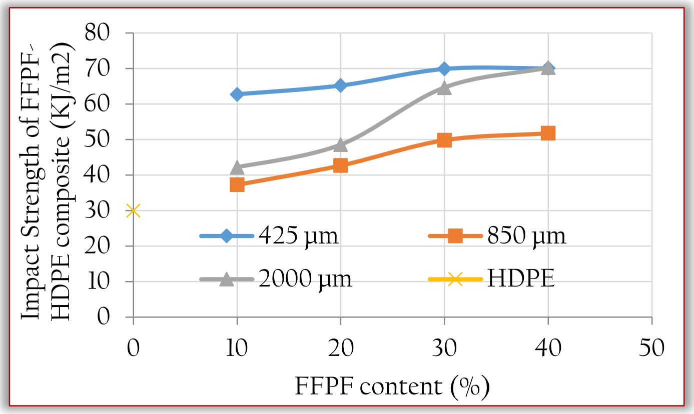
(a)



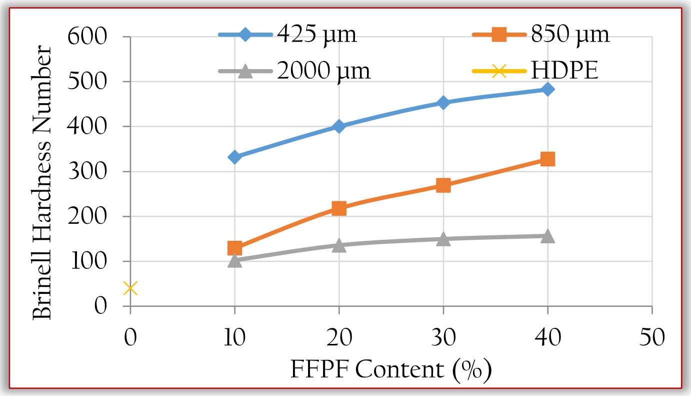
(b)



(c)



(d)



(e)

Figure 4. FFPF content on the (a) tensile strength (b) elongation (c) Young's modulus (d) impact strength (e) Brinell hardness number of FFPF-HDPE composite.

CONCLUSIONS

This novel filler from FFPF was used as a reinforcing agent for the development of FFPF-HDPE composite, and the FFPF was fully exploited in this research. The FTIR analysis of the crude FFPF, HDPE and FFPF-HDPE composite presents distinguishing structural properties for the raw fiber, thermoplastic and the composite, with displaying evidence of changes in transmittances percentage, disappearances of radicals and visible presence of additional new bonds in the output product which is totally absence in the input. The FFPF content and size had a great influence on the mechanical properties of the FFPF-HDPE composite. Specifically, the introduction of FFPF into HDPE polymer has tremendously improved the mechanical-characteristics of FFPF-HDPE composite with exception of elongation and tensile strength. The data and information realized in this work indicates that the composite can be recommended for domestic use.

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