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Effect of Reinforcement Loading on the Physical and Mechanical Properties of Palm Trunk Ash and Low Density Polyethene

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ABSTRACT: *A composite material is the combination of two or more materials comprising of at least two phases bonded together to produce a material with improved properties. One of these phases is a continuous phase (matrix) while the other is a dispersed phase (reinforcement). The purpose of this project is to determine the effect of mechanical and physical properties of reinforced low density polyethylene with palm trunk ash.Such properties include tensile test, hardness test, flexural test and microstructural test.The equipment used for this research were: metal mould, sieves, digital weighing balance, hack saw, grinding machine, tensometer, universal material tester, digital Rockwell hardness tester and optical microstructural microscope. The matrix material used in this study was a low density polyethene and filler material used was palm trunk ash.The composites were prepared using percentage weight of 0%,10%, 20%, 30%, 40% and 50% of palm trunk ash.The conversion of waste materials to a valuable product was the major target of the author and the results showed that palm trunk ash (PTA) can be used as a reinforcing material on polymeric matrices. The Palm trunk ash at 50% increases the tensile strength thereby increasing the brittleness of the material and reducing the ductility. The tensile strength of VDPE-PTA obtained showed that proper mixture of palm trunk ash and virgin low density polyethene composite are good engineering materials for reinforcement loading. The increase in PTA also decreases the flexural strength of the composite materials which shows that the 0% PTA composite materials have the highest flexural strength. It was also observed that the melting point of the composite materials increase with increase in palm trunk ash.*

KEYWORDS: *Effect, Reinforcement Loading, Properties, PalmTrunk Ash, Low Density Polyethene*

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I. INTRODUCTION

A composite material is a material made from two or more constituent materials with significantly different physical or chemical properties that, when combined willproduce a material with characteristics different from the individualparentcomponents. The individual components remain separate and distinct within the finished structure(Agbede and Manasseh, 2009).

Reinforcement provides strength and rigidity, helping to support structural load. The matrix or binder (organic or inorganic) maintains the position and orientation of the reinforcement. The Book of Exodus in the Christian Bible recorded that straws were used to produce rigidity and strength in mud walls. Historical examples include the use of bamboos as a reinforcing material in mud walls in houses by Egyptians (15000BC) and laminated metals in the forging of swords (1800AD). Since the 1970's the application of composite materials has widely increased due to development of new fibers such as carbon, boron and aramids and new composite systems with matrices made of metal and ceramics (Isiaka and Temitope, 2013).

Callister, (2007) viewed that chemical surface treatment of rice husk ash prepared under special condition is effective in reinforcement only at low filler loading.

The reinforced rubber products with baggase ash fillersand succeeded in improving the tensile strength, abrasion resistance and hardness of rubber composites with increasing filler loading while the elongation at break and compressive strength decreased (Cooke, 1990).

Polyethylene is of low strength, hard and rigid, but has a high ductility and impact strength as well as low friction. It shows strong creep under persistent force, which can be reduced by addition of short fibers and also feels waxy when touched(Callister, 2007).

Low density polyethene(LDPE) is defined by a density range of 0.910–0.940 g/cm^3. It is not reactive at room temperatures, except by strong oxidizing agents, and some solvents cause swelling. It can withstand temperatures of 80 °C continuously and 95 °C for a short time and made in translucent or opaque variations, also quite flexible and tough (Agbede and Manasseh, 2009).

Global polymer production on the scale present today began in the mid 20th century, when low material and productions costs, new production technologies and new product categories combined to make polymer production economical. The industry finally matured in the late 1970s when world polymer production surpassed that of steel, making polymers the ubiquitous material that it is today. Fibre-reinforced plastics have been a significant aspect of this industry from the beginning (Josmin, et al, 2012).

The palm trunk is as old as or older than human civilization itself, starting with the cultivation of the palm by Mesopotamians and other Middle Eastern peoples 5000 years or more ago. The palm trunk not only provided a concentrated energy food, which could be easily stored and carried along on long journeys across the deserts, it also created a more amenable habitat for the people to live in by providing shade and protection from the desert winds. In addition, the palm also yielded a variety of products for use in agricultural production and for domestic utensils, and practically all parts of the palm had a useful purpose (Aku, et al, 2012).

It has been discovered over the years, that effort made to prevent indiscriminate litter of the environment with polymeric and agricultural wastes has been inefficient as these polymeric wastes such as low density polyethylene can be seen littered in most streets in Nigeria (Abdulah, et al, 2011). These led for more effort into the provision of a permanent solution to the problem of polymeric waste disposal in the country and so bring about the motivation for this study. The aim of this project is to determine the effect ofreinforcement loading on low density polyethylene with palm trunk ash in its mechanical and physical properties.

II. MATERIALS AND METHOD

The equipment used for this research were: metal mould, sieves, digital weighing balance, hack saw, grinding machine, tensometer, universal material tester, digital Rockwell hardness tester and optical microstructural microscope.The matrix material used in this study is a low density polyethene. The virgin low density polyethene (VLDPE) was used for experiment. The VLDPE was sourced from the Onitsha main market. The filler material used also is palm trunk ash. Palmtrunk was got from felled palm tree and was cut into palates and was further reduced to strands of 3 to 4 mm and then grounded and sieve.

Figure 1: Palm trunk

Figure 2: Pallets of palm trunk

Figure 3: Reducing the pallets to strands.

Figure 4: Grounded palm trunk (palm trunk ash).

Iron sheets were cut and formed into different sizes which serve as molds forthe test samples. The testing techniques for the materials required that three sets of pattern (tensile, hardness and flexural) should be produced. The patterns were made according to the required dimensions of the test samples. The molds were constructed to within ± Imm to give allowance for machining if necessary and the surfaces were rubbed with wax releaser (groundnut oil) to ensure easy removal of the materials.

The measured volume of VLDPEwere mixed in a container and stirred at low speed for 10 minutes until it became uniformly melted and in full liquid form, removed from the furnace and pour the palm trunk ash filler which will immediately make the mixture to foam. It is allowed to settle and then poured into the mould. Before pouring into the mould, we ensure that the mould is properly lubricated with groundnut oil for easy removal of materials from the mould.

Physical Test (Micro structural Observation)

The test was carried out at material and metallurgy laboratory, Enugu State University of Science and Technology, Enugu, Nigeria. An optical micro structural microscope with magnification 200 was used to determine the micro structural view of the materials of different sample. The microscope is connected to a computer where the microstructure will be viewed on the computer screen by the help of software and then printed out or copied to an external drive for analysis. The six VLDPE-PTA composite samples of different composition were loaded in the specimen chamber one after the other and the views were collected and saved in the computer accordingly.

Tensile Strength of the Samples

Tensile testing of the samples was done at the Strength of Materials Laboratory, University of Nigeria, Nsukka using Hounsfield (Monsanto) tensometer. Turning on the Hounsfieldtensometer and the computer connected to it, loading the correct beam in the Hounsfield, attaching the movable and fixed jaws, setting the mercury indicator, and ensuring that the ends of the test piece were fitted into the grip of the tensometer. Tensile forces were applied gradually by turning the hand wheel of the rotating drum. Turning of the hand wheel of the rotating drum pulled the samples until fracture occurred.The deformations were obtained from the load-extension curve. The traced load-extension curve was converted to stress-strain values. Other tensile properties likeelongation at fracture, tensile strength and young modulus were determined fromthis stress- strain curve.

Hardness

The hardness test was done at the material and metallurgy departmental laboratory, Enugu State University of Science and Technology, Enugu, Nigeria. An automatic electric powered Rockwell hardness testing machine was used to determine the hardness value of the VLDPE-PTA composite. The machine was switchon and the desired load of 30kgf was selected,placing the surface of the specimen to be tested on the anvil of the machine and releasing the indenter of the machine from the lever until it touched the specimen making a green to be shown to indicate test zone specimen. Pressing the test button and there was automatic indentation of the specimen by the conical shaped indenter of the Rockwell tester.
At the end of the indentation a red light showed “read” and instantly reading was directly done from the dial indicator.

Flexural Strength

The flexural strength test was done at the material and metallurgy departmental laboratory, Enugu State University of Science and Technology, Enugu, Nigeria. Each specimen of dimension 80mm by 40mm by 10mm was placed in the flexural testing machine. The three point flexing and loading arrangement was used in which fracture occurred at the middle.
The specimen was flexed and flexural force that fractured the specimen at the
middle was read from the scale of the machine. The flexural strength and strainwas calculated using equation 1 and 2.

$$\text{Flexuralstrength}(Fs) = \frac{Fl}{bd^2} \qquad \text{(Ishiaka and Temitope, 2013)} \qquad 1$$

Where ,
l = gauge length (mm)
b = breadth (mm)
d = thickness (mm)
Fs = flexural strength.

$$\text{Strain } (\mathcal{E}) = \frac{6sb}{l^2} \qquad \text{(Ishiaka and Temitope, 2013)} \qquad 2$$

Where,
s = deflection

b = breath
l = guage length

Thermal Properties

This test wascarried out at foundry workshop, Faculty of Engineering, Enugu State University of Science and Technology, Enugu, Nigeria. This is done using a fabricated furnace. The six samples of the VLDPE-PTA composites were cut into same size and placed in the furnace at 0^0Cand turned on. The furnace is checked withthe interval of every 4^0C to know which melts first and the reading is taken accordingly. This particular thermal test is just for the melting point of the composites materials.

III. RESULTS AND DISCUSSION

The results of the study are presented in the figures below. The results of physical properties like weight, moisture contents, optical microstructural microscope and Mechanical properties and thermal behavior behaviour of the VLDPE-PTA composites materials were determined and compared. Optical microstructural microscope showed the microstructure of the composites and the thermal behavior showed the melting points of the different composition of the composites materials.

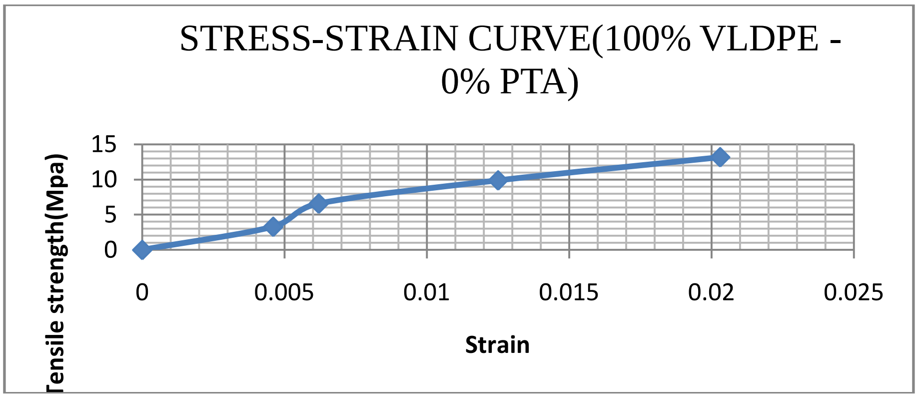

Figure 5: Tensile test for 100% VLDPE-0% PTA

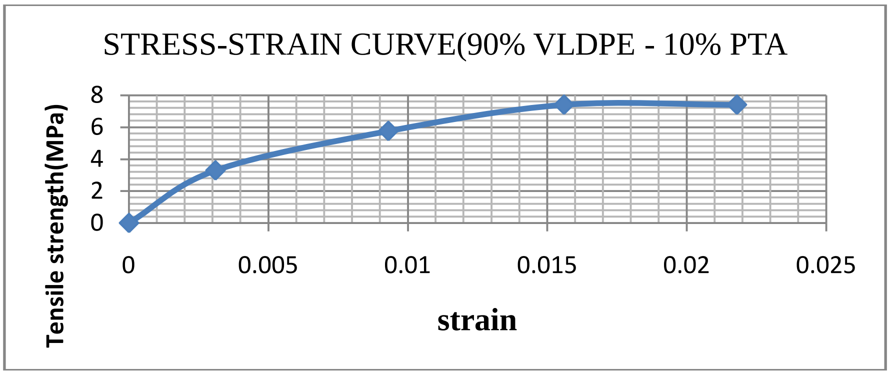

Figure 6: Tensile test result for 90% VLDPE - 10% PTA

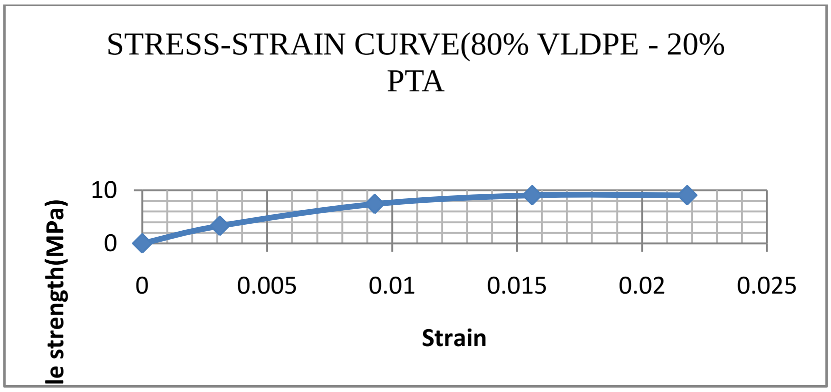

Figure 7: Tensile test result for 80% VLDPE - 20% PTA

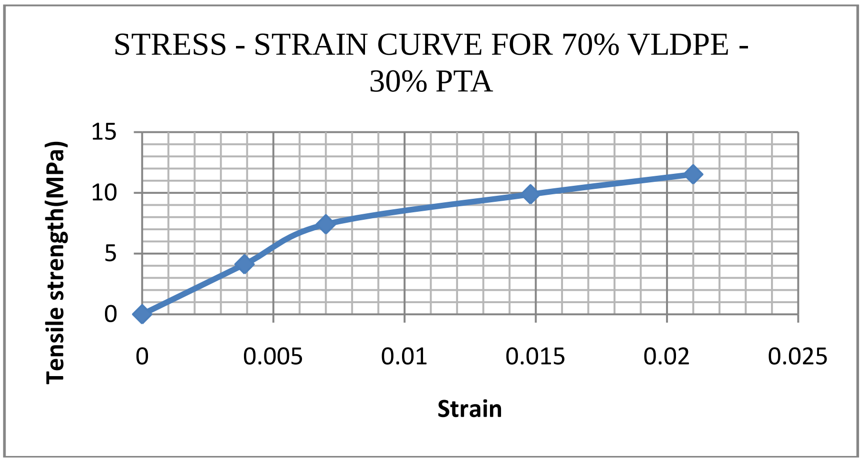

Figure 8: Tensile test result for 70% VLDPE - 30% PTA

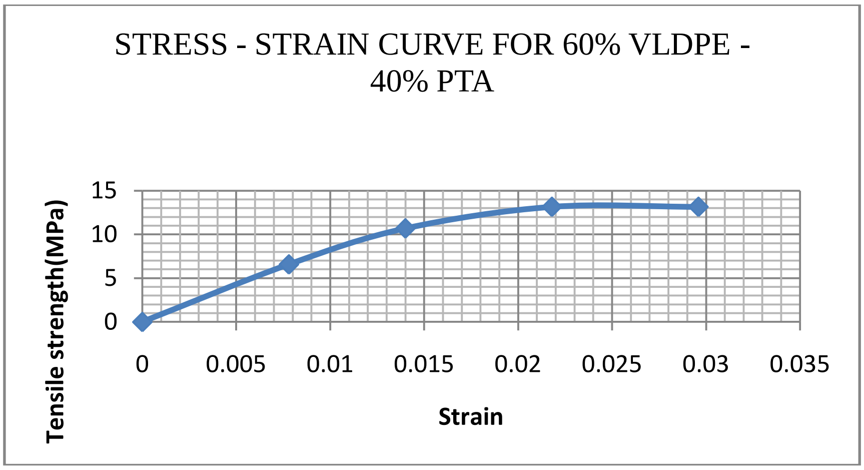

Figure 9: Tensile test result for 60% VLDPE - 40% PTA

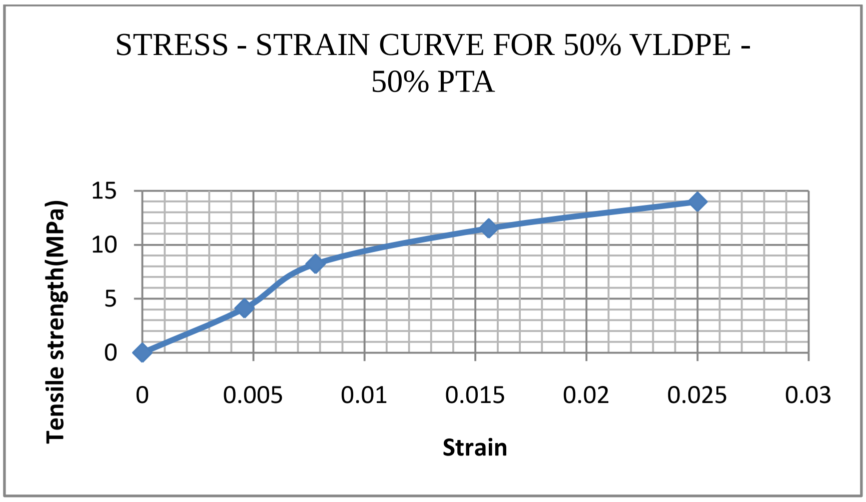

Figure 10: Tensile test result for 50% VLDPE - 50% PTA

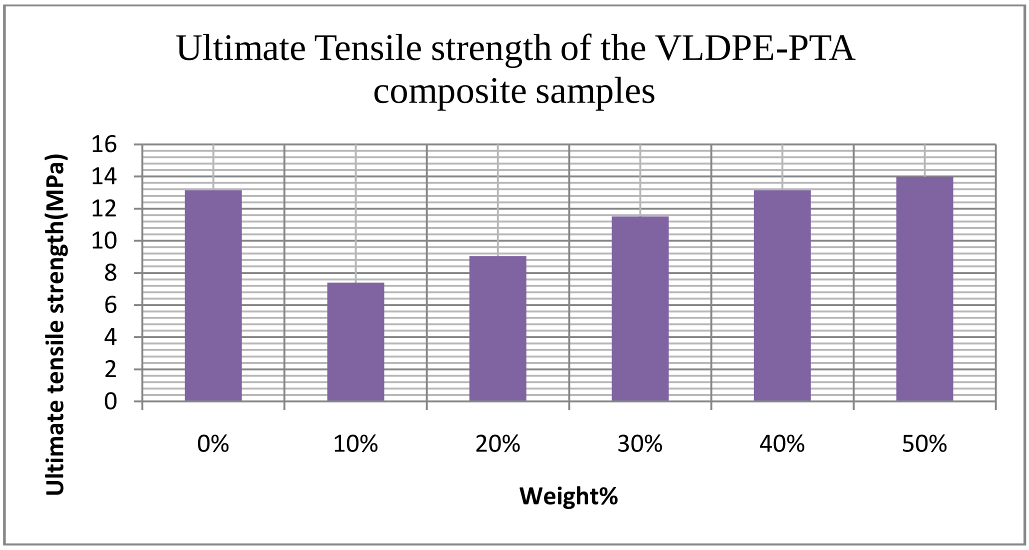

Figure 11: Ultimate tensile strength of the VLDPE-PTA samples

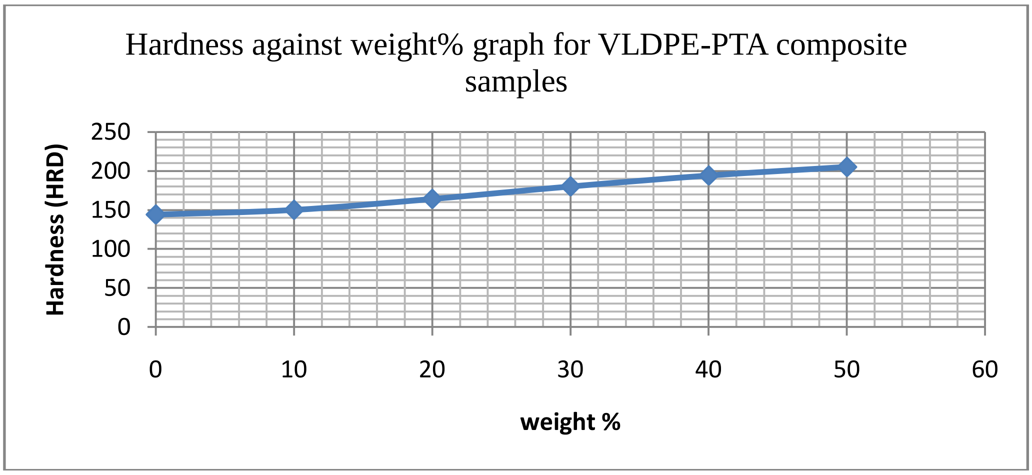

Figure 12: Hardness test result for VLDPE-PTA composite samples

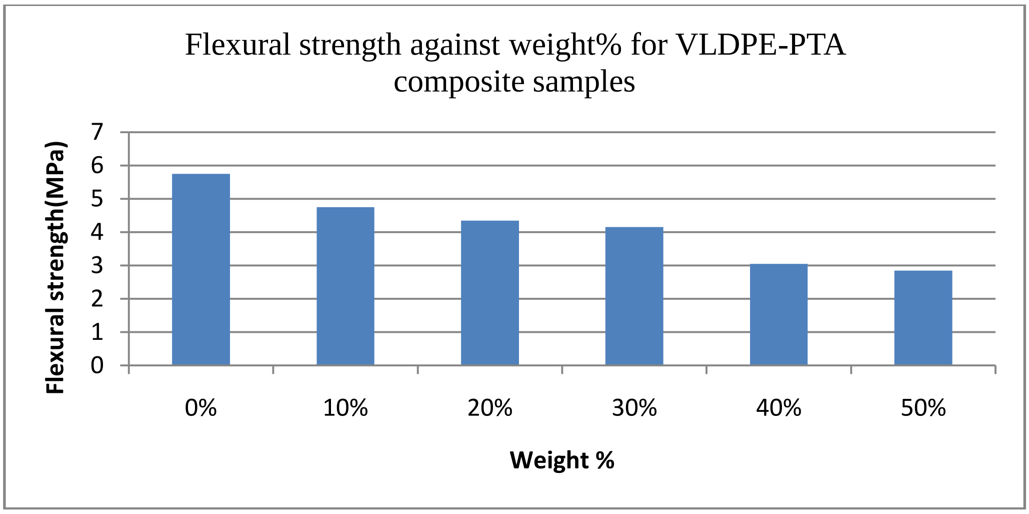

Figure 13: flexural strength of the VLDPE-PTA composite samples

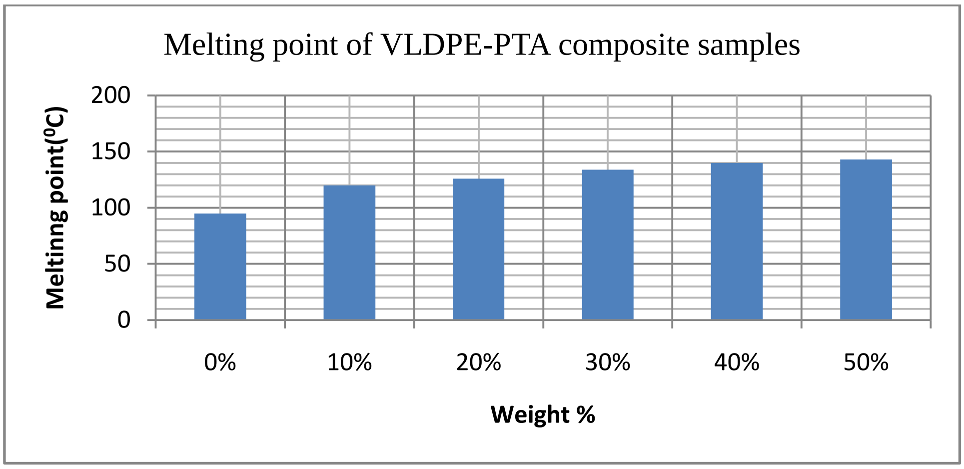

Figure 14: Melting points of VLDPE-PTA composite samples

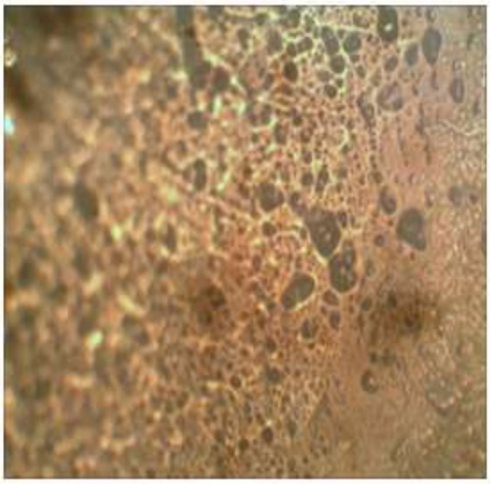

Figure 12: Microstructural view of 100% VLDPE- 0%PTA **Figure 13 :** Microstructural view of 90% VLDPE- 10%PTA

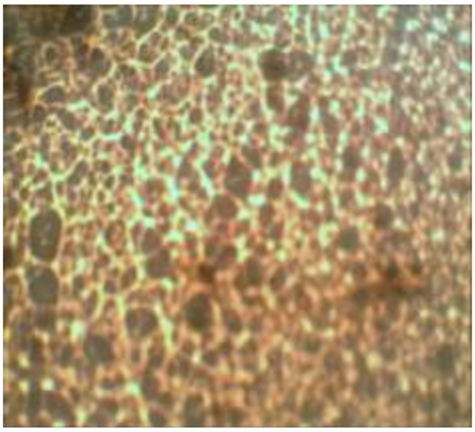

Figure 14: Microstructural view of 80% VLDPE-20%PTA **Figure 15:** Microstructural view of 70% VLDPE- 30%PTA

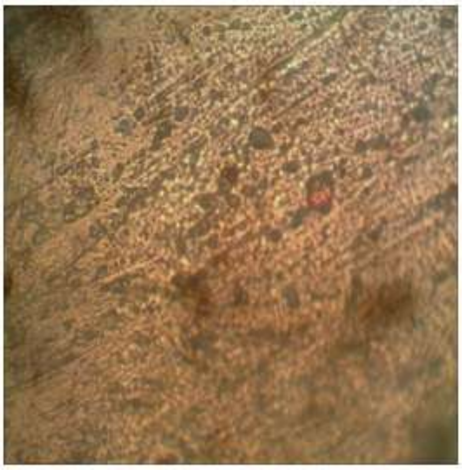
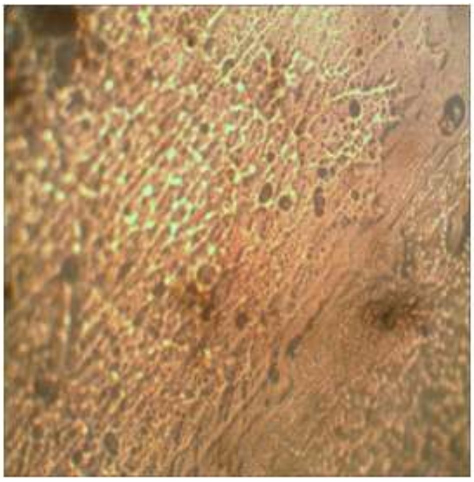

Figure 26 : Microstructural view of 60% **Figure 37**: Microstructural view of 50%
VLDPE- 40%PTAVLDPE- 50%PTA

The figures 5 to 10 showed stress versus strain graphs of the materials. From these graphs it can be seen that the materials were slightly brittle. The reason for the brittleness is because the composites did not sustain large deformations before fracture and some of the stress-strain diagrams had no yield point. Figure 11 shows the ultimate tensile strengths of the composites material. The tensile strengths of the composites with 10%, 20%, 30% and 40% volume of PTA were lower than the 0% PTA while the highest tensile strength of 13.908MPa for the VLDPE-PTA was recorded at 50% volume of PTA. The reasons for this result are: tensile strength was affected by volume fractions, degree of adhesion between the filler and the matrix, level of dispersion of the filler and matrix and surface related defects. Tensile strength can decrease with increasing filler content if the filler matrix adhesion is weak and these accounts for the reason why the tensile strength of 10%, 20%, 30%, and 40%volume fraction of PTA were lower than that of 0% PTA. However the reasons for the higher tensile strength of the 50% PTA could be because there is more palm trunk ash in it. This may mean that at a particular volume of palm trunk, the tensile strength will start increasing. Also it might also be because there were strong interfacial adhesions between the palm trunk ash fillers and low density polyethene matrix or better stirring during the production process. The fluctuation of the graph is because manual mixing was used which caused irregular dispersion of the palm trunk ash in the low density polythene.

The hardness value of the composites increases from 144 to 205 for virgin low density polyethene with increase in percentage of palm trunk ash as shown in figure 12. This increase is due to the hard nature of palm trunk ash. The hardness of the palm trunk ashwould not allowed quick penetration of the indenter on indentation. Hard material embedded in a softer material most times result in increase of hardness.

The bar chartof flexural strength versus percentage weigh of palm trunk ash in figure 13 shows that as the percentage weight of palm trunk ash increases, then, the flexural strength decreased as well. Flexural strength is the ability of material to resist bending, twisting and deformation under load. The reasons for the decrease in flexural strength were poor interfacial adhesion (bonding) between the palm trunk ash and the low density polyethene matrix, distortion in the microstructure caused by addition of palm trunk ash and porous morphology of the palm trunk ash. These defects accounted for lower resistance of LDPE - PTA composites to flexural force leading to quick rupture.

From the figure 14, it can be observed that the melting points of this composites increase with increase in volume faction of percentage PTA. This is as a result of the addition of the palm trunk thereby increasing the strength of the bonds.

The figures 12 to 17 show optical microstructural of the composites of 0 to 50% palm trunk ash. The physical examination was determined with the aid of microscope.

IV. CONCLUSION AND RECOMMENDATION

The conversion of waste materials to a valuable product was the major target of the author and the results showed that palm trunk ash (PTA) can be used as a reinforcing material on polymeric matrices. The Palm trunk ash content at a particular volume fraction (50%) increases the tensile strength thereby increasing the brittleness of the material and reducing the ductility. The tensile strength of VDPE-PTA obtained showed that proper mixture of palm trunk ash and virgin low density polyethene composite are good engineering materials for reinforcement loading.Increase in palm trunk ash (PTA) also increases the hardness of the composite materials as shown from the results. The increase in PTA also decreases the flexural strength of the composite materials which shows that the 0% PTA composite materialshave the highest flexural strength.It was also observed that the melting point of the composite materials increase with increase in palm trunk ash.

Other methods should be considered for the production of the composite, at fillercontents higher than those used for this study (preferably at 10t% weight increment), to see ifthe method of production of the composite would provide a better composite material ascompared with the compression molding method used for this work.

The degradability test should be carried out for a period of 6 to12 months to determine the level of degradation that may occur over an extended period of timeand further microscopic test such as Scanning Electron Microscope (SEM) that can analyze the microstructural view of the composite.

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