ISSN-L: 2223-9553, ISSN: 2223-9944
Vol. 4 No. 1 January 2013

STUDIES ON THE PROPERTIES OF PINE-APPLE LEAVES POWDER FILLED LOW DENSITY POLYETHYLENE

S. C. Nwanonenyi[1], P.I. Anyanwu[2]

Department of Polymer and Textile Engineering,
Federal University of Technology Owerri, Imo State,
NIGERIA.

[1]simyn22@yahoo.co.uk, [2]naoplac2006@yahoo.com

ABSTRACT

Pulverized pine-apple leaves of particle sizes 150µm and 300µm respectively with varying (3, 6, 9, 11, 14) wt % were incorporated into Low Density Polyethylene with the aid of single screw extruder fitted with a slit die at temperature of 130^{0}C to obtain desired and enhanced properties. Some mechanical and end-use properties of pine-apple leaves powder/low density polyethylene composite were investigation. The parameters such as tensile strength, elongation at break, tensile modulus, and hardness test were carried out on the prepared composite samples. Experimental results showed that tensile modulus and hardness increased with increase in filler loading, while tensile strength and % elongation at break decreased with increase in filler loading. Water absorption behaviour of the composites as function of time of exposure investigated increased as the time of exposure and filler content increases. The specific gravity of the composite samples as a function of filler content determined depicts significant increase as filler loading increased, whereas, flame propagation rate as function filler loading decreased with increase in filler loading.

Keywords: Pulverized Pine-apple Leaves, Low Density Polyethylene, Tensile strength, %Elongation, Modulus of elasticity, End-use Properties.

INTRODUCTION

The urgent need for materials with low cost, weight reduction and enhanced mechanical properties has led to the development of composites (Crawford, 1987). However, the involvement of plastics in the development of composites for engineering applications has been posing great challenges to materials Scientists and Engineers (Powell, 1984). This is because of vehement objection to the use of plastics in a large number of engineering applications due to their poor thermal and mechanical properties, as well as, ageing resistance when compared to light metals and woods (Schwartz & Goodman, 1980). In order to overcome these constraints especially where light weight and low cost are very essential, composites have been developed in which plastics materials and fillers are the major constituents (Jacobbs & Kilduff, 1958). A number of mineral and natural fibre fillers have been used to fill polyethylene, and are reported in scientific literature. For instance Najafi et al. (2006) reported the study on composite of saw-dust and virgin and/or recycled HDPE. The flexural and tensile properties, and impact strength of the composited produced were determined by the standard procedures. Results showed that the mechanical properties of the composite containing recycled HDPE and virgin HDPE are statistical similar and comparable. Liang (2007) investigated the tensile, flow, and thermal properties of $CaCO_3$-filled HDPE/LLDPE composites produced using a twin-screw extruder. The results showed that the tensile elastic modulus increased roughly linearly with increase in weight fraction of the fillers. Sapuan et al. (2005) reported the study on tensile and flexural strength of coconut spathe and sapthe fibre reinforced epoxy composite. The results showed that tensile strength of coconut sapthe-fibre is inferior to other natural fibre such as cotton, coconut coir and banana fibres, and suggest that fibre treatment may improve the interfacial bonding between fibre and matrix leading to better mechanical properties of coconut sapthe-fibre reinforced composite laminates. Madufor (2007) studied some mechanical properties of cassava filled LLDPE. The results showed that water absorption of the composite increased with increase in filler addition, while the tensile properties decreased with increase in filler addition. Other report in the scientific literature includes the work of Sadiku et al. (2008) who investigated the mechanical and rheological characteristics of micro-particle maize tassel/polypropylene composite. The results showed that young's modulus and activation energy of the composite from rheological test increased with increase in filler loading, while impact strength, work of rupture, % strain, dynamic storage modulus decreased with increase in filler loading. The effects of different compatibilizer on the properties of wood flour/saw-dust polymer matrix composite reported by Angels et al. (1996), Patil et al. (2000), Lai et al. (2003), Wang et al. (2003), Chauhan et al. (2006), and Pilla et al. (2008). Since efficient utilization of existing polymers and natural fillers give room for synthesis of fresh samples of polymer composites, this research work is aimed at studying the effect of incorporating pulverized pine-apple leaves into a commodity thermoplastic with a view to investigate the behaviour of the filler and recommend for subsequent use in large scale production, better means of disposing the waste materials instead of open burning, and to improve the dimensional and biodegradable characteristics of the matrix.

EXPERIMENTAL

The materials used for the study include Low density polyethylene with density of 0.922g/cm^3 and melt flow index (MFI) of 4.0g/10min at 190^{0}C. It is produced by Thai Polyethylene Co Ltd, China. Pine-apple leaves were collected from a local farm at Ozubulu in Ekwusigo L.G.A. The leaves were pulverized with the aid of grinding machine, and particle sizes of 150µm and 300µm were obtained.

Preparation of the Test Sample

Each component of test composite sample (LDPE and Pulverized pine-apple leaves powder) was measured out on weight basis using a digital weighing machine as shown in table 1.0. The premixed matrix and filler of each test composite sample were melt- blended and extruded using a single screw extruder fitted with a slit die, operating at speed of 100rmp and 130^{0}C. This process was repeated for other different test composite samples. The test composite samples were cut into dumb-bell shape with following dimensions: 135mm X 14mm X 2.0mm.

Table 1.0: The formulation of the composite samples

ID	*LDPE (%wt)*	*Pine-Apple Leaves Powder(%wt)*
A	100	0
B	100	3
C	100	7
D	100	11
E	100	15

PROPERTY MEASUREMENT

Tensile Properties

Tensile test accordance to ASTM D638 was evaluated using universal tensile testing machine of LR10K and from which the tensile strength, % elongation at break, and modulus of elasticity values were obtained. Hardness shore D was used to measure the hardness of the composite sample, and average readings of the samples tests were considered.

END-USE PROPERTIES

Specific Gravity

Specific gravity test was determined (according to ASTM D 729 procedure) using an analytical balance and a beaker as an immersion vessel. A thread was used in suspending the specimen in air and water during measurement. The test specimen of dimension 50 X 30 X 2.0mm was weighed in air (a) and later immersed completely in water (b) and the weights were recorded. This process was repeated for other test samples and the specific gravity was calculated using the expression;

$$\text{Specific gravity} = (W_a / W_b) \times 100$$

Where W_a = weight of test sample in air, W_b = weight of test sample in water.

Water Absorption

Water absorption test was carried out in accordance with the ASTM D570 test procedure. The test sample of dimension 50 X 30 X 2.0mm was first weighed in air and later immersed in water completely for 24hrs at room temperature. Excess water in the surface of the test sample was wiped out with filter paper before re-weighing. This process was repeated for other test samples. The percentage water absorption was calculated determined as follows;

$$\%\ \text{Water Absorption} = ((W_w - D_w) / D_w) \times 100\%.$$

Where W_w = Wet weight of test sample, D_w = Dry weight of test sample.

Flame Propagation

Flame Propagation test was determined (according to ASTM 635 test procedure) by measuring the time taken to burn a known length of the specimen. A test sample of size 130 X 30 X 2.0mm was marked at 120mm and 130mm from one end and clamped horizontally. The test sample was ignited with a cigarette lighter and the time taken to burn from 120 to 130mm was noted and recorded. The rate of burning was determined using the expression given as follows;

$$\text{Flame Propagation rate (mm/s)} = D_p / (P_t - I_t).$$

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

RESULTS AND DISCUSSION

Mechanical Properties

Tensile Strength

The result of tensile strength shown in Fig 1 revealed that the tensile strength of the composite decreased with increase in filler loading for the different particle sizes investigated. This is because the presence of filler did not restrict the mobility of the molecular chain, thus strengthening of the polymer matrix, packing characteristics and interfacial bonding between the matrix and filler was poor leading to decrease in strength.

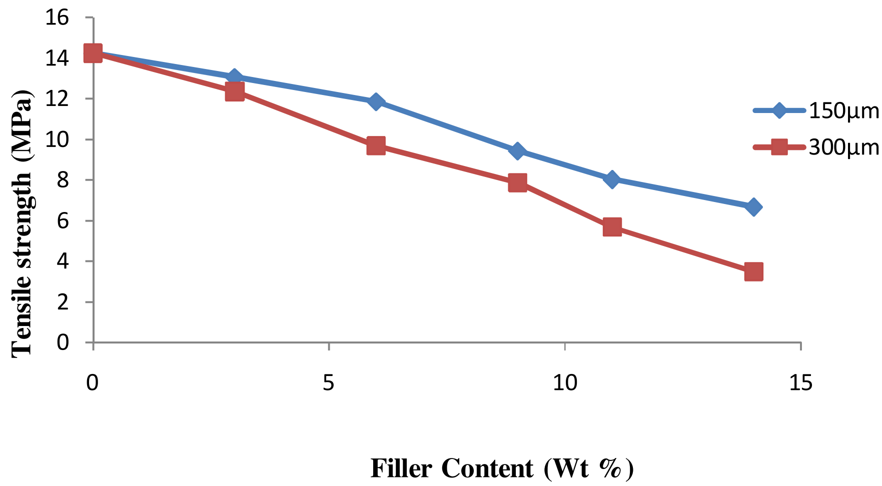

Fig 1. Plot of Tensile Strength against Filler Content

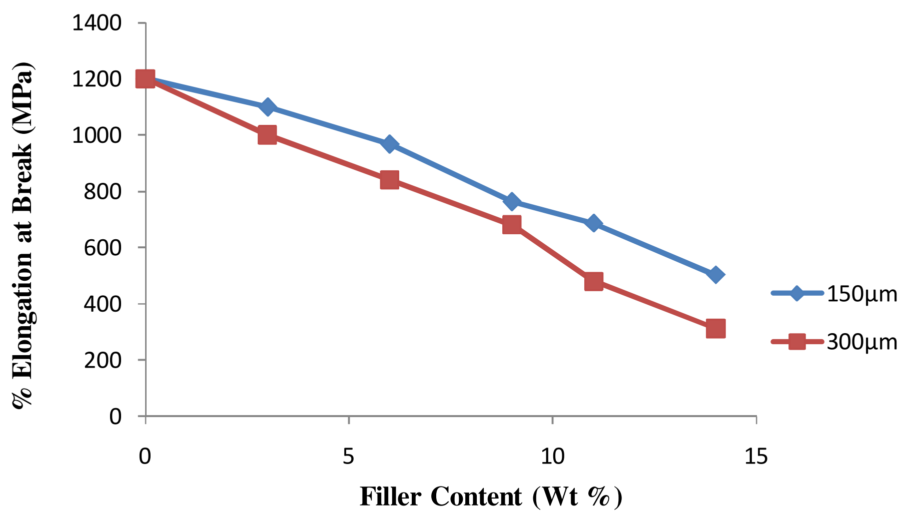

Fig 2. Plot of % Elongation at Yield against filler loading

Percentage Elongation at Break

The result of percentage elongation at break as shown in Fig 2 revealed that % elongation at break of the composite samples investigated decreased with increase in filler loading. This is because the presence of filler imparts the stiffening effect within the matrix and thus imposed a mechanical restraint on the composite.

Modulus of Elasticity

The result of tensile modulus as shown in Fig 3 above revealed that tensile modulus increased with a corresponding increment in the filler loading for the composite samples examined. The observed increase in the tensile modulus is due to improvement in the stiffness of the composite as filler addition increases. It is as a result of the stiff nature of the filler structure.

ISSN-L: 2223-9553, ISSN: 2223-9944
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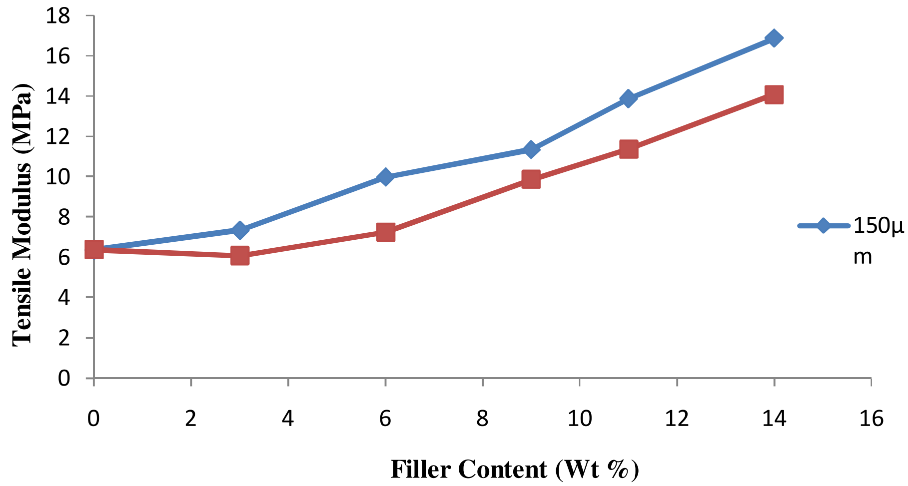

Fig 3. Plot of Tensile Modulus against Filler Content

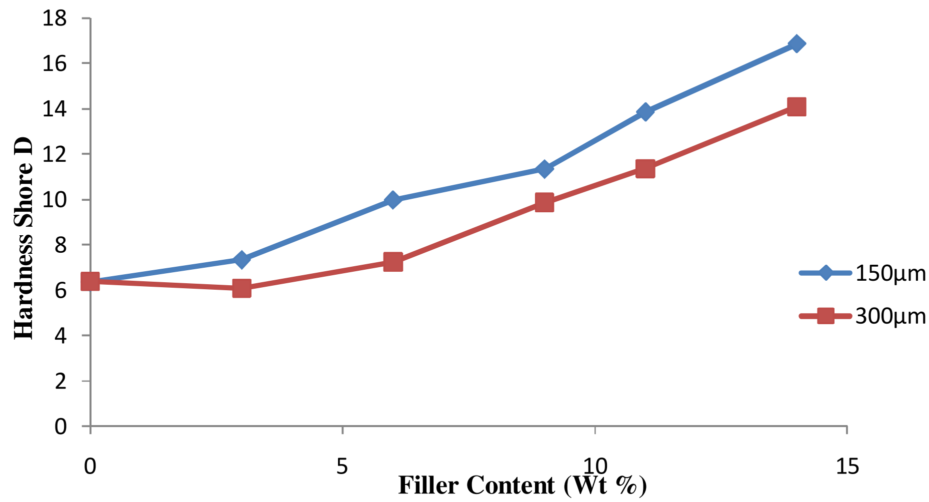

Fig 4. Plot of Shore D Hardness against filler loading

Hardness Test

The result of hardness test is shown in Fig 4. It is observed that hardness increased as filler content increases. This is because the filler stiffened the molecular chain of the matrix, thereby reducing the mobility of chain which helps in improving the hardness of the composite material as filler content increases.

END-USE PROPERTIES

Flame Propagation Test

Fig 5 shows the result of flame propagation rate behaviour of the composite as a function of filler content. It is observed that flame propagation rate of the composite samples investigated decreased with increase in filler addition. The improvement in the flame retardant property of the composite investigated is due to low flame spread characteristic property of the filler. Hence, it is believed that powdered pine-apple leaves do not support combustion.

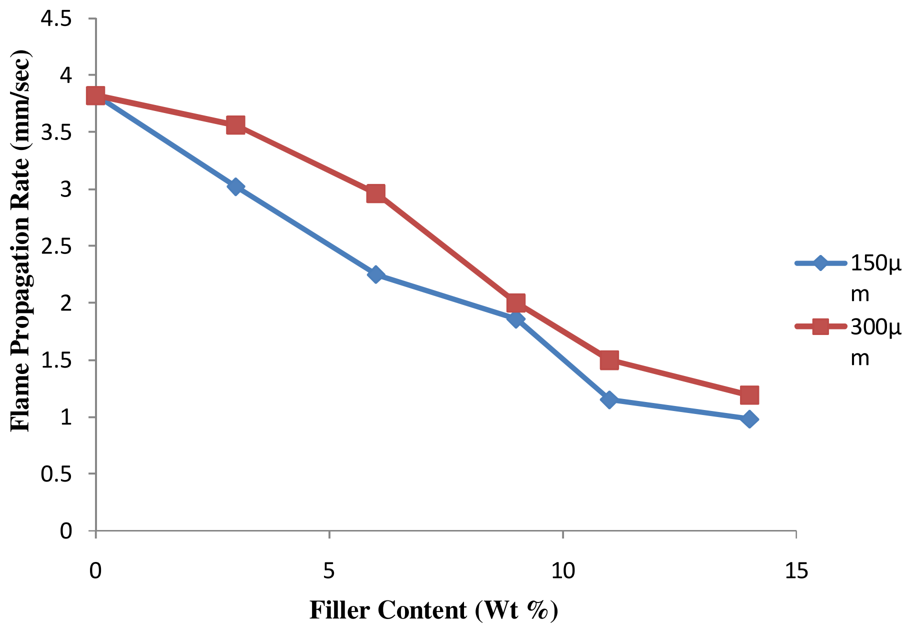

Fig 5. Plot of Flame Propagation Rate against filler loading

Specific Gravity Test

The specific gravity property of the composite samples as a function of filler content is shown in Fig 6. The result presented a gradual increase in the composite samples as the filler content increases. This is because the presence of filler particles adds its weight on the matrix which increases density of the composite.

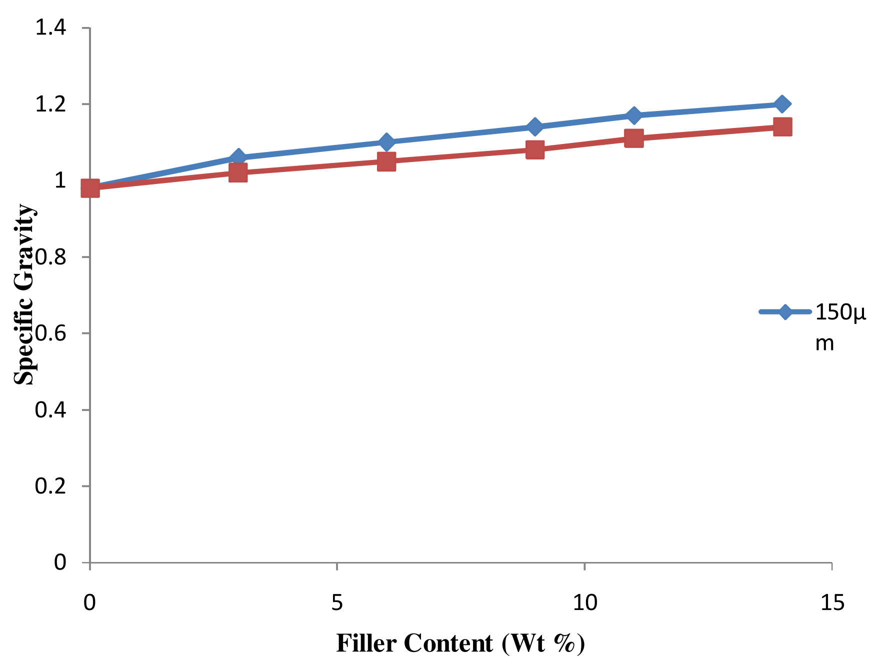

Fig 6. Plot of Specific Gravity against filler loading

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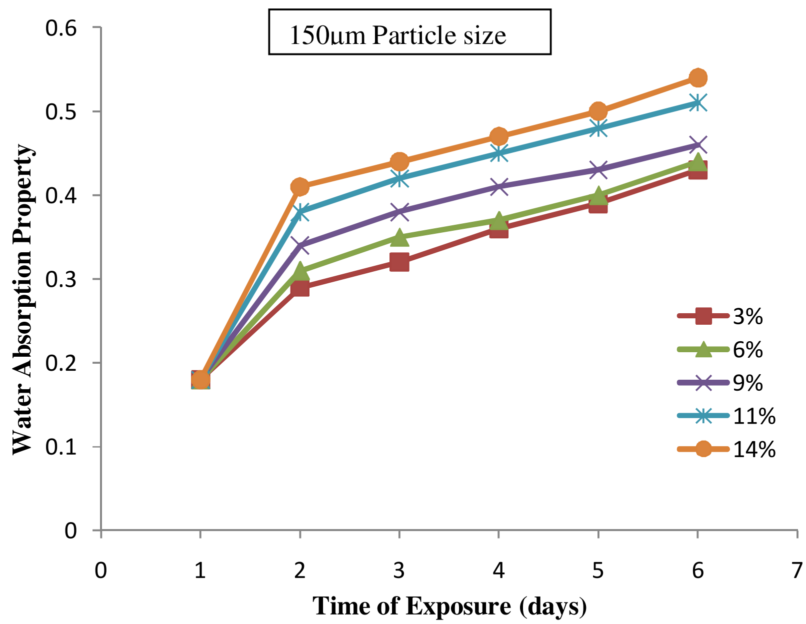

Fig 7. Water Absorption of Composite sample Versus Time of Exposure

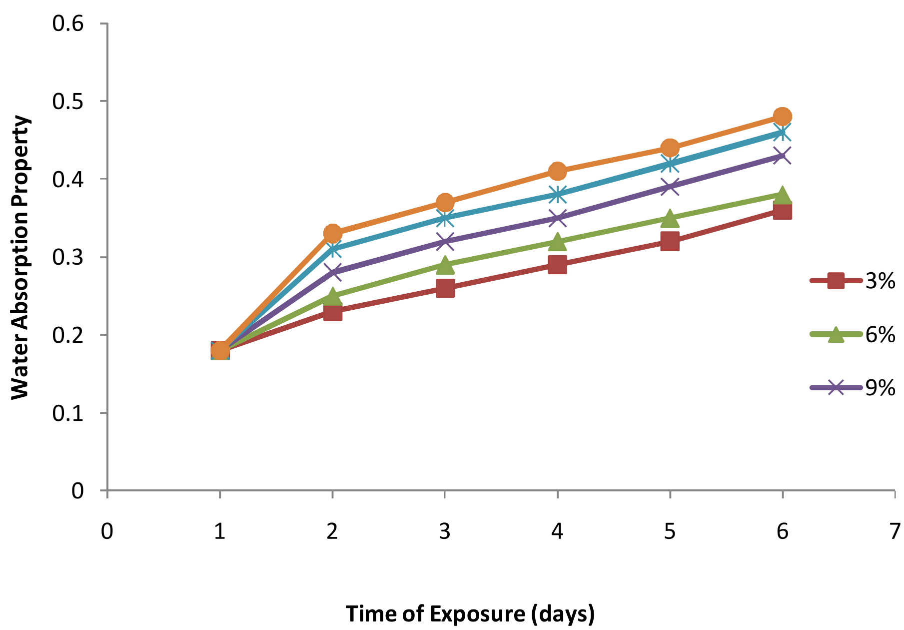

Fig 8. Water Absorption of Composite sample Versus Time of Exposure

Water Absorption Test

The results of water absorption as a function time of exposure are shown in Fig 7 and Fig 8 respectively. It showed that water absorption property of the composite increased as the filler content increases. This is because the presence filler particles increased pores within the composite, thereby increasing the water absorption capacity of the composite.

CONCLUSIONS

The incorporation of pulverized Pine-apple leaves into Low Density Polyethylene showed a significant increment in tensile modulus and hardness as the filler content increases, whereas tensile strength and percentage of elongation decreased with increase in filler loading. A significant increase in water absorption, specific gravity and decrease in flame propagation rate property was observed with increase in the filler loading. The research does not anticipate total replacement of inorganic fillers with agricultural waste materials. It is expected that with improvement on research and development that pine-apple leaves will develop their own niche in the plastics design and manufacturing, offer further opportunities in the plastics industries and contribute positively to the economic well being of the local farmers.

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ISSN-L: 2223-9553, ISSN: 2223-9944
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