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ABSTRACT

Snail shell powder, a material of animal origin was used as a biodegradable filler and incorporated into low density polyethylene, LDPE, resins to produce green composites of LDPE. The range of added snail shell powder of particle size of 83µm at varying percentages of 0%, 2%, 6% and 10% was added into LDPE. The composites were produced using injection moulding machine. Its effects on the mechanical properties of the polymer composites were tested; which include the tensile strength, percentage elongation at break, flexural strength and hardness. The surface morphology of the polymer composites was analysed via optical microscropy. The results showed that the filler had positive impacts on the mechanical properties of the polymer by increment in tensile strength from 128.29MPa to 137.56 MPa, flexural strength from 120.34 MPa to 145.76MPa and hardness from 43kN to 74kN. While the percentage elongation at break decreased from 200.16 to 168.34. Thus, snail shell powder was found to show great reinforcing properties in the prepared composites and can be used to improve some mechanical properties of polymers since it is organic, cheap, available, eco-friendly and biodegradable material.

Keywords: snail shell powder, low density polyethylene, mechanical properties, optical microscopy.

Classification: FOR Code: 039999

Language: English

London Journals Press

LJP Copyright ID: 925634
Print ISSN: 2631-8490
Online ISSN: 2631-8504

London Journal of Research in Science: Natural and Formal

Volume 18 | Issue 4 | Compilation 1.0

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I. ABSTRACT

Snail shell powder, a material of animal origin was used as a biodegradable filler and incorporated into low density polyethylene, LDPE, resins to produce green composites of LDPE. The range of added snail shell powder of particle size of 83µm at varying percentages of 0%, 2%, 6% and 10% was added into LDPE. The composites were produced using injection moulding machine. Its effects on the mechanical properties of the polymer composites were tested; which include the tensile strength, percentage elongation at break, flexural strength and hardness. The surface morphology of the polymer composites was analysed via optical microscropy. The results showed that the filler had positive impacts on the mechanical properties of the polymer by increment in tensile strength from 128.29MPa to 137.56 MPa, flexural strength from 120.34 MPa to 145.76MPa and hardness from 43kN to 74kN. While the percentage elongation at break decreased from 200.16 to 168.34. Thus, snail shell powder was found to show great reinforcing properties in the prepared composites and can be used to improve some mechanical properties of polymers since it is organic, cheap, available, eco-friendly and biodegradable material.

Keywords: snail shell powder, low density polyethylene, mechanical properties, optical microscopy.

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II. INTRODUCTION

The wide spread of plastic products in various applications has attracted greater attention due to their unique properties, which include good mechanical properties, resistance to chemical attack and corrosion, ease of processing and recycling, cost effective, light weight, and others. However, these properties are affected by many factors such as stress, temperature and environment when plastics are exposed to service or during processing [1]. Recently, polymer composites containing natural fillers have been more and more widely used in the processing industry, particularly in polymer processing [19]. Polymer composites have unique properties, which is why they are used in different branches of industry [9]. In order to obtain products with the required functional properties, polymers are physically modified by the use of fillers. The properties of the produced composite material are significantly affected by interactions between the polymer matrix and the filler [2]. Considerable interest has been generated in the manufacture of thermoplastic composites due to their unique properties, including their good mechanical properties, their thermal stability, and a reduced product cost [6, 5]. The attempts to overcome these obstacles led to incorporation of fillers (inorganic and organic) into plastics with a view to obtain a plastic composite whose constituents act synergistically to withstand the challenges, thereby making plastics more reliable during use or processing.

Some filler materials of organic origin have been investigated for making polyethylene composites. These materials included egg shell [19], feather, hide and cow hoof [11,12], flax [7], hemp strand [8], green coconut fibre [15] and bamboo-corn husk [13].

This article reports an investigation on the mechanical properties and morphology of snail shell powder in a LDPE/snail shell powder composites.

III. MATERIALS AND METHODS

3.1 Sample collection and preparation

The low density polyethylene, LDPE used in this study was obtained from Ceeplast Industries Limited Aba, Abia State, Nigeria. The snail shell powders were sourced locally from Ochanja Market in Onitsha South, Anambra State, Nigeria. The snail shells were washed with clean water to remove the adhered contaminants and sun-dried for 3 days. The snail shells were crushed, ground and sieved using an electrical standard sieving machine of Model D210, Made in Italy. Fine powder with particle size of 83µm was obtained. Fig.1 shows the snail shells before preparation and powdered snail shells after preparation.

Fig.1: Snail shell and Snail shell powder

3.2 Polymer composite preparation

The low density polyethylene composites were prepared by thoroughly mixing 208.10g of crystalline low density polyethylene with the filler (snail shell powder) at varying percentages of 0%, 2%, 6% and 10% were properly weighed with weighing balance. These were pelletised to ensure a homogenous mixture of the polymer and filler. The mixed pellets were then poured into the hopper of an injection moulding machine of Model 4.6KW, 10H Made in Chain, with a rectangular shaped mould with dimensions of 57mm X 13.5mm X 3.2mm. The composites were produced by Ceeplast Plastics Co. Ltd., Aba, Abia State, Nigeria.

A total of four samples were prepared, the volumetric relation between snail shell powder and low density polyethylene (LDPE) was modified according to the following composition as shown in Table 1.

Table 1: % Snail shell powder and low density polyethylene composition

% Filler Load	% LDPE
0	100
2	98
6	94
10	90

3.3 Mechanical Tests

The following mechanical tests; tensile strength, elongation at break and flexural strength tests were carried out as described in American Standard Testing and Measurement, ASTM D638 by using the Instron universal testing machine 5569, Model 6.5KW, Made in China. While the surface hardness of the polymer composites were determined by the means of Avery Hardness Testing machine, Type 6406, Number E65226, manufactured by Avery Birmingham, England. The corresponding value of the diameter of the indentation at that surface was recorded and the hardness was calculated with the formula as Birnell Hardness Number measured in N/mm²;

$$BHN = \frac{2P}{nD(D\sqrt{D^2-d})} \quad \text{.......... (1)}$$

Where P = load x 9.81
D = diameter of Indentor (mm) D^2
d = diameter of impression (mm) and Λ = 3.142

3.4 Optical microstructure

The optical microstructure analysis was performed using Nikon Eclipse ME600 optical microscope to show the surface morphology of the filler and polymer matrix. This was carried out in the Department of Polymer Science, Engineering Materials Development Institute, Akure, Ondo State, Nigeria.

3.5 Results and Discussion

The mechanical properties of the low density polyethylene/snail shell powder composites with varying filler loads for the four different percentage filler were determined. The results are as discussed below.

3.6 Tensile Strength

The tensile strength shows the ability of a material to withstand shear stress/strain. The Fig.2 shows the tensile properties of the composites.

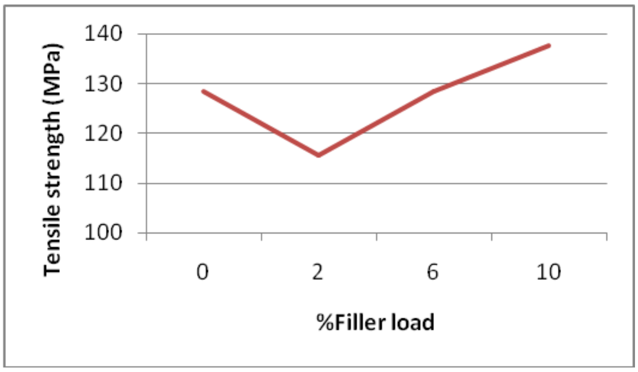

Fig.2: Effect of filler loading on the tensile strength of snail shell powder-filled LDPE composites

From Fig.2, it is clear that the incorporation of snail shell powder into the low density polyethylene increased the tensile strength of the composites from 128.29MPa in the unfilled test piece to 137.56MPa in %10 filled composite. Though a decrease of 115.62MPa was observed at 2% filler load but it gradually increased from 6% to 10% filler load. The increased tensile strength for the snail shell powder filled LDPE composites could be due to a better interfacial adhesion between the filler and polymer matrix. Strong adhesion between the filler and matrix interface can cause better stress transfer from the matrix to the filler leading to a higher tensile strength. This is in agreement with the works of some other researchers [19, 10, 12].

3.7 Elongation at break

This expresses the ability of a material to resist changes of shape without crack formation. Result of the % elongation at break of the filled composites is shown in Fig.3.

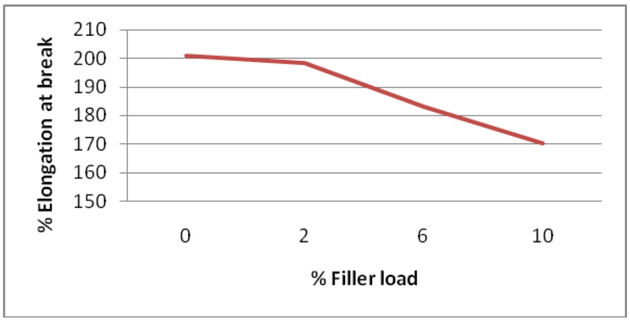

Fig.3: Effect of filler loading on % elongation at break of snail shell powder-filled LDPE composites

It can be seen from Fig.3 that the % elongation at break for the composites decreased with increasing filler loading with unfilled specimen having % elongation at break of 200.16, while the 10% filled LDPE composite had the least value of 168.34 % elongation at break. The increased filler loading in the LDPE matrix resulted in the stiffening and hardening of the composite. This reduced its resilience and toughness, and led to lower elongation at the break [19]. The reduction of the elongation at break with the increasing filler loading indicates the incapability of the filler to support the stress transfer from filler to polymer matrix.

3.8 Flexural strength

The flexural strength also known as modulus of rupture, or bend strength is the stress in a material just before it yields in a flexure test. It represents the highest stress experienced within the material at its moment of yield [3]. The result of the flexural strength is as depicted in Fig.4.

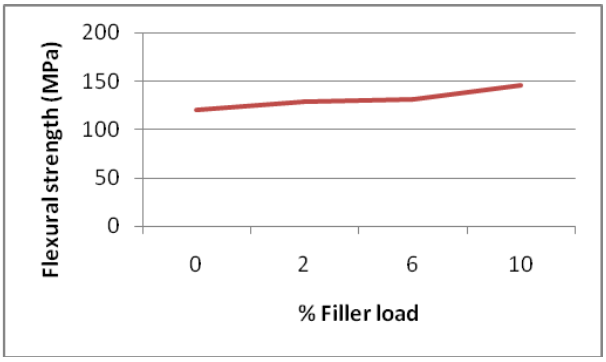

Fig.4: Effect of filler loading on the flexural strength of snail shell powder-filled LDPE composites

Flexural strength of the filled composites, as shown in Fig. 4 above indicates increase in flexural properties as filler load increases, it is observed that the snail shell powder filled composite of 10% has the highest flexural strength of 145.76 MPa when compared with the unfilled LDPE of 0% having the lowest flexural strength of 120.43MPa. It was a gradual increase as the filler load increased. This could be attributed to even distribution of the applied force inside the filled polymer matrix as a result of even dispersion of filler in the polymer matrix and also there was interaction between the filler and polymer matrix. This shows that the snail shell powder can be used as filler in improving the flexural strength of low density polyethylene (LDPE).

3.9 Hardness

Hardness is defined as resistance of a material to penetration or indentation. The result obtained from the hardness test is shown in Fig.5.

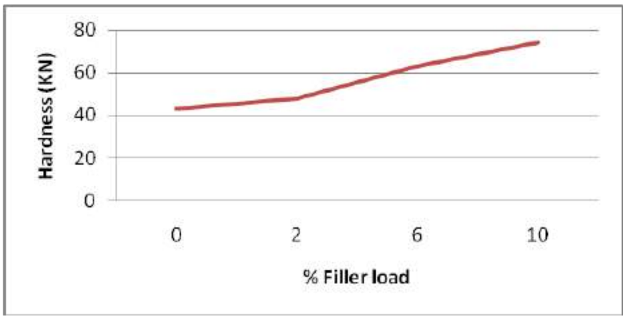

Fig.5: Effect of filler loading on the hardness of snail shell powder-filled LDPE composites

The hardness of a polymer composite depends on factors such as filler hardness, filler grain size and the interactions on the filler-polymer matrix interphase. Powdered filler grains can act as nucleates in the polymer crystalline phase, which results in an increase in hardness of material [4]. The hardness result as seen in Fig.5 showed an increase in the hardness test as the filler load increased, at 0% filler load, the hardness was 43kN, this increased progressively from 2%, 6% to 10% with the corresponding increase in hardness of 48kN, 63kN and 74kN respectively. The filled composites had values more than the unfilled sample. Thus, indicating that the presence of the snail shell powder filler in the polymer matrix improves the surface stiffness of the composites and reinforced its properties. It is also in agreement with other related work [14].

3.10 Optical microstructure of snail shell powder filled LDPE composites

The micrograph structures of the filled polymer composites are shown in Fig.5(a-d).

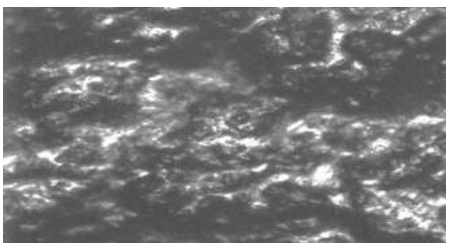

Fig.5(a)

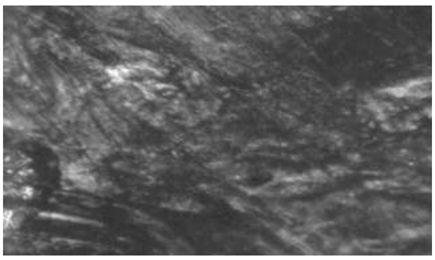

Fig.5(b)

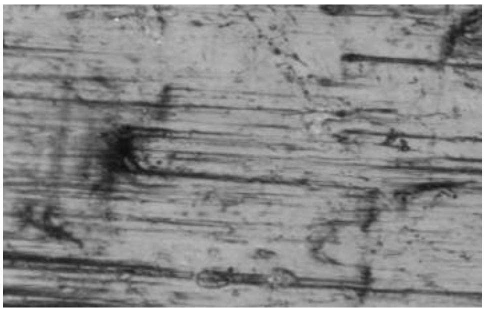

Fig.5(c)

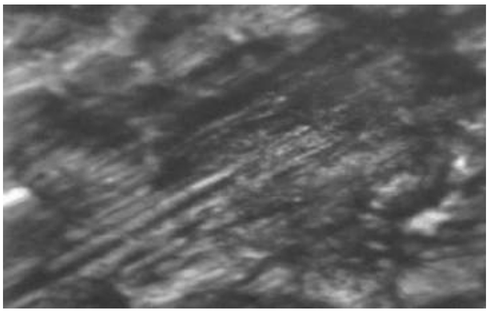

Fig.5(d)

Fig.5(a): shows micrograph of 0% LDPE/snail shell powder composite; (b) shows micrograph of 2% LDPE/snail shell powder composite; (c) shows micrograph of 6% LDPE/snail shell powder composite; (d) shows micrograph of 10% LDPE/snail shell powder composite respectively

From the Figs. 5(a-d); it was observed that there were uneven dispersion and agglomeration of filler particles in the polymer matrix; however, there seem to be an improvement on the dispersion of the filler in the composite matrix as the filler load increases. This also confirms the poor mechanical properties of the composite obtained at lower filler load, which indicates, that as the filler load increases there were improvement on the mechanical properties of the composites. The micrograph shows that the composites are more compatible than the unfilled composites. The filling improves the compatibility by finely dispersing the filler in the polymer matrix. This finding suggests that the adhesion between the matrix and the filler is very good. Accordingly, the interfacial strength is improved [18].

IV. CONCLUSION

The incorporation of snail shell powder as filler into low density polyethylene (LDPE) resins to produce polymer composites was successful. The snail shell powder showed its reinforcing effects on the prepared composites at different filler loadings as it was observed to increase the mechanical properties of the composites. Thus, the mechanical properties of the composites produced were found to depend on polymer matrix-filler interaction, particle size and distribution of the fillers particles within the matrix.

This study has pointed the advantage of using snail shell powder as filler for low density polyethylene which has a vast application especially as packaging material. Hence, from the results obtained, it can be suggested that the wide of use of low density polyethylene can be enhanced as the snail shell powder is used as filler.

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