Available online at www.pelagiaresearchlibrary.com

Pelagia Research Library

Advances in Applied Science Research, 2014, 5(2):286-291

ISSN: 0976-8610
CODEN (USA): AASRFC

Effects of reinforcement loading on physical and mechanical properties of developed recycled low density polyethylene/maize cob ash particulate (PLDP/MCAp) composite

[1]Chike V. Chira, [1]Anthony I. Obi, [1]Danjuma S. Yawas, [2]Victor S. Aigbodion, [1]David O. Obada and [1]Ibraheem A. Samotu

[1]Department of Mechanical Engineering, Ahmadu Bello University, Zaria, Nigeria
[2]Department of Metallurgical and Materials Engineering, University of Nigeria, Nsukka

---

ABSTRACT

Efforts made to recycle empty water sachet (commonly called pure water nylon) and maize cob, into a useful material of good physical and mechanical properties have been reported. The effects of reinforcement loading on the physical and mechanical properties of the developed composite material have now been established. The empty water sachet was used as a matrix, which was reinforced by maize cob ash particulate and the composites were compounded and compressively moulded. The results obtained reveal that both the physical and mechanical properties measured such as hardness values, density, young's modulus, flexural strength and impact energy increase with loading of the maize cob ash particulate up to a range of 20-25wt% MCAp loading then fall on further addition. For optimum service conditions, maize cob particles addition should not exceed 25% to ensure better performance.

Key words: Composite, Maize cob ash, Properties, Automobile, Bumper.

INTRODUCTION

Polymer composite materials are being used in a wide range of structural applications in the aerospace, construction and automotive industries due to their lightweight and high specific stiffness and strength [1]. A variety of materials are being used ranging from low performance glass fibre/polyester, used in small sail boats and domestic products, to high performance carbon fibre epoxy systems used in military aircraft and spacecraft. One sector where the use of composite materials is still evolving is the automotive industry. The use of polymers in United States automotive applications has risen dramatically from an average of 18 pounds per vehicle in 1960 to well above 300 pounds per vehicle in 2004 (8% of vehicle weight) [2]. Notably, most of the plastic applications in vehicles are low-performance commodity polymers and short-fiber composites. The use of advanced composites in structural vehicle body has been far less extensive, but there are recent applications where they have been significantly used [3]. Composite part production success relies on the correct selection of a manufacturing technique as well as judicious selection of processing parameters [4].

A lot of research has been carried out in the area of composite development and study of effects of reinforcement loading on the properties of the developed composite material [6-10]. Some on development of composite for automobile application [11,12] and many on suitability of some natural filler reinforced composite material [13-19].

This current research is aimed at studying the effects of the introduction of maize comb ash on the properties of a composite material, which is environmental friendly, recyclable, and made from renewable natural sources.
Therefore, the specific objectives of this research are as follows:

i. Evaluation of the variation in the physical properties of the developed composite material with increase in MCA loading and,
ii. Evaluation of the variation in the mechanical properties of the developed composite material with increase in MCA loading.

Finally, the major contributions of this research work include the following:

i. It has given insight to the effects of MCA loading on the selected properties of the developed composite Material.
ii. It has stated clearly, the optimum loading of MCA in the composite for applications of known functional requirement.

MATERIALS AND METHODS

Materials and Equipment that was used in this research are-,Maize cob, pure water sachet, Metal mould, hydraulic press, Avery Denison impact tester, Rockwell hardness, Instron machine, grinding and polishing machine and Scanning electron microscope (SEM).

2.1 Characterization of Maize Cob

The maize cob was subjected to the following processes before use:-

i. Chemical treatment of the maize cob was done by soaking it in sodium hydroxide solution.
ii. The processing of the maize cob into maize cob particles which involved collection, drying and grinding of the cob to form powder after treatment.
iii. Carbonization of the maize cob powder was done using graphite crucible which was fired in electric resistance furnace at temperature of 1200^{o}C.
iv. The particle size analysis of the maize cob particles was carried out in accordance with BS1377:1990, the particles that were retained in the BS. 300µm and 100µm mesh sieves were obtained and labeled (MCLp) and (MCSp) respectively. The two groups were used separately to reinforce the composite.

2.2 Sample preparation

The fabrication of the various composite materials was carried out through the compressive technique. Maize cob ash particle (MCS and MCL) are reinforced with RLDPE. After drying in an oven at 105^{o}C, the maize cob ash particles and the RLDPE was compounded in a two roll mill at a temperature of 130^{o}C, into a homogenous mixture. The composites production was carried out on an electrical heated hydraulic press. The mixtures were placed in a rectangular mould with a size of 350mm by 350mm. The composites were pressed to a thickness of 4mm. At the end of press cycle the composites was removed from the press for cooling. 5-30wt% of maize cob ash particles was used with interval of 5wt%. Five different types of composites were fabricated with two different maize cob particles (MCS and MCL).

2.3 Microstructural Analysis

The scanning electron microscope (SEM) JEOLJSM-6480LV was used to identify the surface morphology of the maize cob ash and composite samples. The samples were washed, cleaned thoroughly, air- dried and are coated with 100A thick platinum JEOL sputter ion coater and observed on the SEM at 20kV. The digitized images were recorded.

2.4 Test Procedure

Test samples were cut from the composites developed for the properties tests according to the recommended standard for each test.

2.4.1 *Determination of Density*

The basic method of determining the density of composite samples is by measuring the mass and volume of the sample used. A clean sample is weighed accurately in air using a laboratory balance and then suspended in water. The volume of the sample was determined from the volume of water displaced (Archimedean principle). The density of the sample was estimated using equation below.

$$Density = \frac{Mass}{Volume} \qquad (1)$$

2.4.2 *Water Absorption Determination*

Specimens with dimensions of 50 mm x 50 mm were prepared for evaluation of the water absorption. The masses of the test specimens were measured with a digital balance. Then the test specimens were place into water in parallel for 30 mm and soaked for 24 h before further measurement of the weight of the soaked samples. The values of the water absorption as percentages were calculated as follows [20].

$$WA_{(t)} = \frac{W_{(t)} - W_0}{W_0}\, x\, 100 \qquad (2)$$

Where WA (t) is the water absorption (%) at time t, W_0 is the initial weight, and W(t) is the weight of the sample at a given immersion time t.

2.4.3 *Tensile test*

The tensile properties of the composite sample was conducted on Instron machine with a strain rate of $2x10^{-3}S^{-1}$ as specified by the American Society for testing and Materials (1990).

2.4.4 *Static Bending Test*

A static bending test (dry) was conducted according to American society for testing materials standard D1037 on specimen of size 150x50x4mm, the test was conducted using bending speed of 10mm/min at 67% relative humidity at 23^{o}C. The bending strength was calculated from load deflection curves according to the following formula [20].

$$MOR = \frac{3P_bL}{2bh^2} \qquad (3)$$

Where P_b is the maximum load (N), b is the width of the specimen (mm), h is the thickness of the specimen (mm), and L is the span (mm).

2.4.5 *Impact Energy Test*

The impact test of the composites sample was conducted in accordance with (ASTM D256-93, 1990) using a fully instrumented Avery Denison test machine. Charpy impact test was conducted on notched samples. Standard square impact test samples measuring 75 x 10 x 10 mm with notch depth of 2 mm and a notch tip radius of 0.02 mm at angle of 45^o were used. Before the test sample was mounted on the machine, the pendulum was released to calibrate the machine. The test samples were then gripped horizontally in a vice and the force required to break the bar was released from the freely swinging pendulum. The value of the angle through which the pendulum has swung before the test sample was broken corresponded with the value of the energy absorbed in breaking the sample and this was read from the calibrated scale on the machine.

2.4.6 *Hardness Test*

The hardness test of composites is the relative resistance of the surface to indentation by an indentor of specified dimension under a specified load. Hardness of the composites was determined by Rockwell hardness machine (BS903 part A 26)(ASTM, 1990) using 1.56mm steel ball indenter, minor load of 10kg, major load of 100kg. Before the test, the mating surface of the indenter, plunger rod and test samples were thoroughly cleaned to remove dirt, scratches and oil and calibration of the testing machine was done using the standard block. The samples were placed on anvils, which act as support for the test samples. A minor load of 10kg was applied to the sample in a controlled manner without inducing impact or vibration and zero datum position was established, then the major load of 100kg was applied. The reading was taken when the large pointer came to rest or had slowed appreciably and dwelled for up to 2 seconds. The load was removed by returning the crank handle to the latched position and the hardness value was read directly from the semi automatic digital scale.

RESULTS AND DISCUSSION

3.1 Surface Morphology of the Maize cob ash

Morphology of the maize cob ash by SEM with EDS is shown in Plate 1. The micrograph reveals that the maize ash particles were are solid in nature (precipitators), but irregular in size. Some spherical shape particles can also be seen in the microstructure. The microstructure consists of only C, Si, O, Al, Ca, as a result of the EDS scan done on the rectangle label (see Plate 1). From the EDS, chemical analysis shows that SiO_2, carbon and CaO were the major constituents and silicon dioxide, carbon, alumina are known to be among the hardest substances. Some other oxides viz. MgO, K_2O, Na_2O was also found to be present in traces. The presence of hard elements like SiO_2, Al_2O_3 suggested maize cob ash to be used as particulate reinforcement in RLDPE.

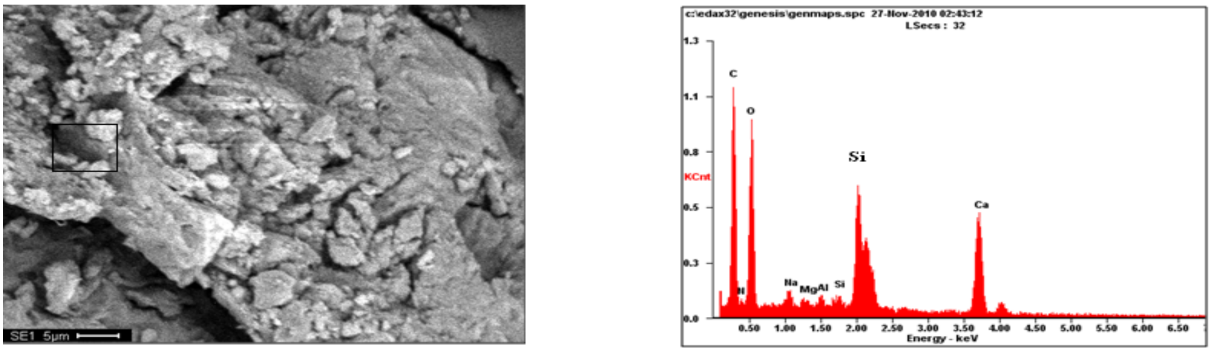

Plate 1: SEM/EDS of the microstructure of the maize ash particles

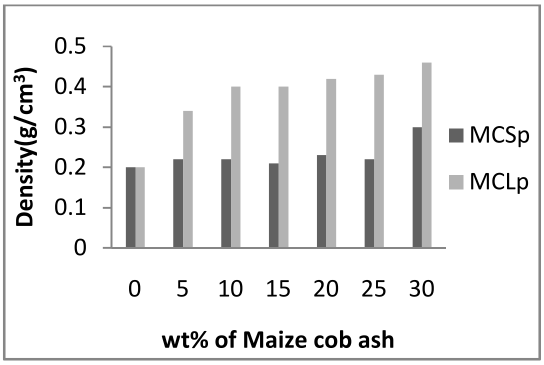

Figure 2: Plot of Density with Maize cob ash

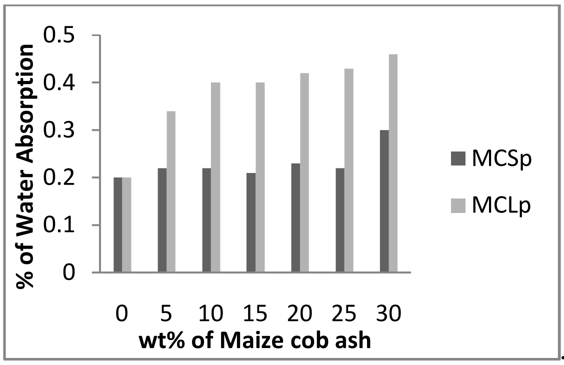

Figure 3: Plot of Water Absorption with Maize cob ash

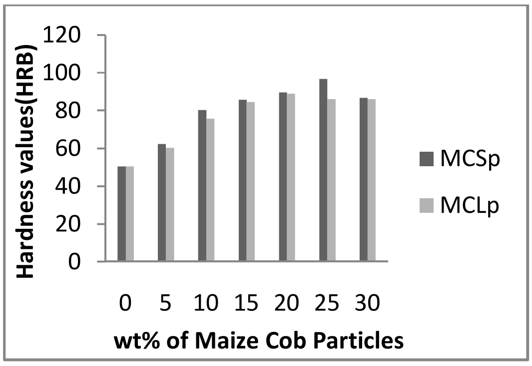

Figure 4: Plot of Hardness values with Maize cob ash

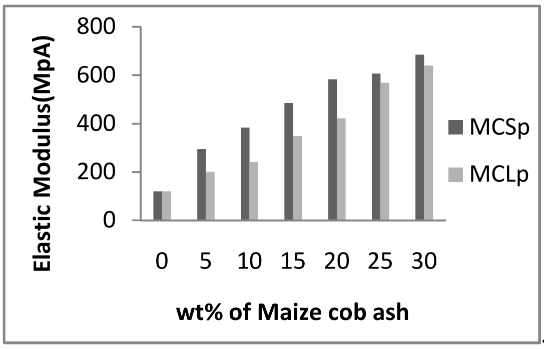

Figure 5: Plot of Elastic Modulus with Maize cob ash

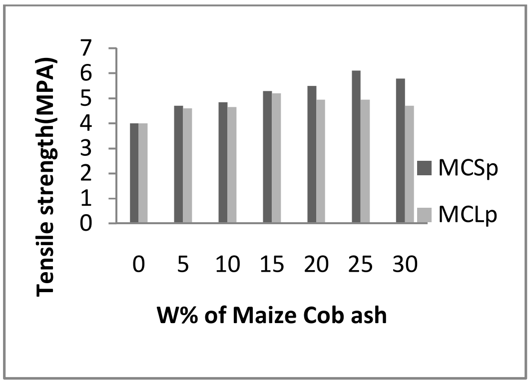

Figure 6: Plot of Tensile strength with Maize cob ash

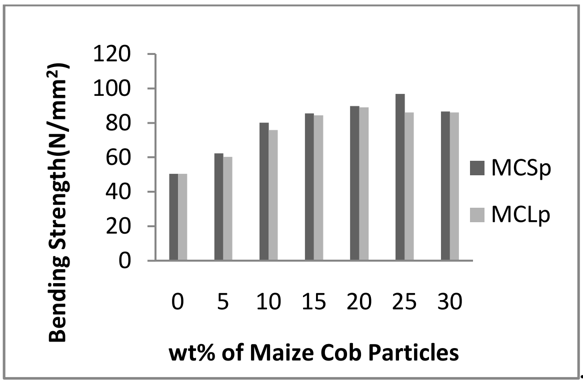

Figure 7: Plot of Bending Strength with Maize cob ash

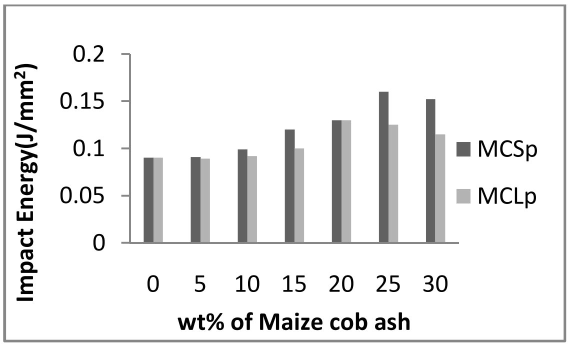

Figure 8: Plot of Impact Energy with Maize cob ash

The results reveal that the presence of maize cob ash particulates slightly increased the density of the PMCs. Since the density of the reinforced PMCs particles composites increased from 0.75 g/ cm^3 at 0wt% of maize cob ash addition to 1.18g/ cm^3 and 1.22g/ cm^3 at 30wt% of maize cob ash addition for MCSp and MCLp respectively. This implies that increase in the loading of the MCA particles increases the density of the developed composite irrespective of the particle size (see Fig. 2).

There is increase in the rate of water absorption with increase in the loading of the MCA. The low level of water absorption recorded may be associated with the surface treatment of the maize cob ash with NaOH solution and better interfacial bonding between the RLDPE and the maize cob particles which resulted into low porosity (see Fig. 3).
Also, mechanical properties like hardness, tensile strength, modulus, bending strength of the developed composite as well as Impact energy absorbed by them increase with increase in percentage loading of the reinforcement up to certain composition mostly 25% loading then the properties begin to decline (see Fig. 4-8).

The hardness values of the composite samples increases as the percentage maize cob ash particles (MCSp and MCLp) addition increases in the RLDPE matrix. The increase in modulus elasticity with increasing maize cob particles addition is expected since the addition of maize cob particles to the RLDPE increases the stiffness of the composites. It is also interesting to note that bending strength increased with increase in maize cob particles in the RLDPE matrix. For example bending strength of 50.50N/mm^2 was recorded for the RLDPE matrix and 96.70N/mm^2 at 25wt% MCSp and 89.00N/mm^2 at 20wt% MCLp respectively. There is an improvement in bending strength of the composite as particle weight fraction increases.

CONCLUSION

From the results analyses done in the previous section, following conclusions can be made;
1)Increase in the loading of the MCA particles increases the density of the developed composite irrespective of the particle size.

2)There is increase in the rate of water absorption with increase in the loading of the MCA though its highest is less that 5ppt
3)Mechanical properties like hardness, tensile strength, modulus, bending strength of the developed composite as well as Impact energy absorbed by them increase with increase in percentage loading of the reinforcement up to certain composition mostly 25% loading then the properties begin to decline.
4)The developed composites has better properties at the ranges of 20-25wt% MCAp additions, and for optimum service condition, maize cob particles addition should not exceed 25% in order to ensure better performance.

REFERENCES

[1] Arnold WS, Marshall IH, and Wood J, *Composite Structures,* **1990**, 16.
[2] Eusebi E, *PNGV Symposium on structural material challenges*, **1995**.
[3] Minaudo BP, Rawson J, and Montone M., *SAE Technical paper 970483*, **1997**.
[4] Mazumdar SK, *Technology and Engineering,* (CRC Press, USA, **2002**) 392.
[5] Cheon SS, Choi JH, and Lee DG, *Composite Structures*, **1995**, 32, 491-499.
[6] Madugu IA., Abdulwahab M. and Aigbodion VS., *Journal of Alloys and Compound*, **2010**, 808-811.
[7] Azam T, Din M, Hameed BH, and Ahmad AL, *Journal of Hazardous Materials*, **2009**, 161, 1522–1529.
[8] Nilza GJ, Vernon GV. and Buchanan E, *Journal of material characterization*, **2007.**
[9] Murali K., Mohana RK, *Composite Structure*, **2007**.
[10] Samotu IA, Madakson PB, Dauda M, Alabi A A, Umar A. and Owolabi OA, *Proceedings of Nigerian Metallurgical Society Conference, Abuja, Nigeria*. **2012,** 28, 95-104.
[11] Aishat Y, *B. Eng Thesis* (Ahmadu Bello University, Zaria, Nigeria, **1998**).
[12] Abdulwahab S, *B. Eng Thesis* (Ahmadu Bello University, Zaria, Nigeria, **2002**).
[13] Salmah H, Ruzaidi CM. and Supri AG., *Journal of Physical Science*, **2009**, 20 (1), 99–107.
[14] Herrera-Franco PJ, and Valadez-Gonza'lez A, *Journal of Composites*, **2005**, 36 (B), 597-608.
[15] Mizanur RM, Mubarak A. and Khan B, *Journal of Composites Science and Technology*, **2007**, 67, 2369–2376.
[16] Noraiham M, Andanastuti M, Mariyam JG, Dahlan HM. and Che HA, *European Journal of Scientific Research, ISSN 1450-216X*, **2008**, 24 (4), 538-547.
[17] Sezgin E. and Haluk K., *Journal of* Applied Acoustics, **2009**, 70, 215–220.
[18] Savita D, and Preeti V, *Advances in Applied Science Research*, **2012**, 3 (3), 1463-1465.
[19] Rajeev J, Kaith BS, Hemant M and Reena S, *Advances in Applied Science Research*, **2011**, 2 (2), 19-27.
[20] BS EN 319 (The British Standards Institution, London, **1993**).