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Suitability of maize cob particles and recycled low density polyethylene for particleboard manufacturing

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ABSTRACT

The aim of this study was to investigate the suitability of maize cob particles and recycled low density polyethylene(RLDPE) as a raw material for particleboard manufacturing. The board was produced by varying RLDPE from 30-70wt% at 10wt% interval. The microstructure, physical (thickness swelling (TS), water absorption (WA)), and mechanical (modulus of rupture (MOR), modulus of elasticity (MOE), internal bond (IB)) properties of particleboards were determined. The results showed that the WA and TS values were moderate, the MOR exceed the minimum requirements of the European standards, for general purpose. All of the particleboards produced had IB higher than the requirement. Hence maize cob particles and RLDPE can be used as a substitute to wood- formaldehyde based particleboard for general purpose applications.

KEYWORDS

Particleboard;
Physical properties;
Mechanical properties;
Microstructure.

INTRODUCTION

Wood composite industries demand more wood raw material everyday despite the fact that the forest resources are diminishing. The decline in wood material source has led researchers to study non-wood ligno-cellulosic biomass utilization in composite manufacturing including particleboard[1, 2]. Agricultural waste materials and annual plant fiber have become alternative raw materials for the production of particle or fiber composite materials. Traditionally, particleboard has been made out of wood-based fibers bound together using a formaldehyde resin. The desired thickness is achieved by using a hot press that forms the board into sheets[3, 4]. One of the major challenges associated with wood-based particleboard is the used of formaldehyde resin is that formaldehyde is a volatile, colorless gas with a strong odor that is commonly used in industrial processes, particularly in manufacturing building materials[5]. Based on this background this present work is looking at the potential utilization of maize cob particles and recycled low density polyethylene(RLDPE) in particleboard production as supplement and to alleviate the shortage of raw material in forest industry and also as a substitute to formaldehyde resin.

MATERIALS/EQUIPMENT

The maize used in this work was obtained from 'Sabon Gari' area of Zaria in Kaduna state Nigeria. Waste pure water sachet(RLDPE)" used were collected literally from the streets of Zaria, Nigeria. Equipment used in this research are-, Metal mould, hydraulic press, Instron machine, grinding and polishing machine and Scanning electron microscope(SEM).

Method

The maize cob was grind into powder particles, The particles was sieve accordance with BS1377:1990[6] to obtained a size of BS. 100μm. Metal Molds was used in the production of the composite samples. The dimensions and shapes of cavities were made according to the size and shape of the samples as per ASTM Standard D 638-90 for tensile testing and ASTM Standard D 790-97 for flexural testing[7]. The maize cob particles and the waste pure sachet(RLDPE) were mixed by compounding into a homogenous mixture and press at a temperature of 150°C and pressure of 10MPA to form the particleboard samples. The resin(RLDPE) was varying from 30 to 70wt% with 10wt% interval. Scanning electron microscope (SEM) JEOL JSM-6480LV was used to identify the surface morphology of the board composite samples. The samples with dimensions of 50 mm x 50 mm were prepared for evaluation of the thickness swelling. The test samples were place into water in parallel for 30 mm and soaked for 24 h before further measurement of the thickness. The Thickness swelling rate (TS) was determined from the following formula[6].

$$TS_{24} = \frac{(t_{24} - t_o)}{t_o} \times 100$$

Where TS is the thickness swelling rate (%), t_0 and t_{24} are the thickness at the middle of the test specimen . The values of the WA as percentages were calculated[6].

$$WA(t) = \frac{W(t) - Wo}{Wo} \times 100$$

Where WA(t) is the water absorption (%) at time t, W0 is the initial weight, and W(t) is the weight of the sample at a given immersion time t.

Bending strength was determined by concentrated bending load at the center with a span of 15 times the thickness of the specimen. The bending modulus of elasticity (MOE) and modulus of rupture (MOR) were calculated from load deflection curves according to the following formula[6]:

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

$$MOE = \frac{P_{bp}L^3}{4bh^2Y_p}$$

Where P_b is the maximum load (N), P_{bp} is the load at the proportional limit (N), Y_p is the deflection corresponding to P_{bp} (mm), b is the width of the specimen (mm), h is the thickness of the specimen (mm), and L is the span (mm).

The tensile strength perpendicular to the surface was determined. The rupture load (Ps) was determined and internal bond strength was calculated using the following formula[7].

$$IB = \frac{P_s}{bl}$$

Where Ps is the rupture load, and l is the length of the specimen.

RESULTS AND DISCUSSION

Macrostructural studies of the particleboard revealed a uniform distribution of maize cob particles with the RLDPE resin. The distribution of particles is influenced by the compounding of the particle and the resin which resulted to good interfacial bonding (see Figure1)

Figure 1 : Photo of the Maize cob/RLDPE particleboard

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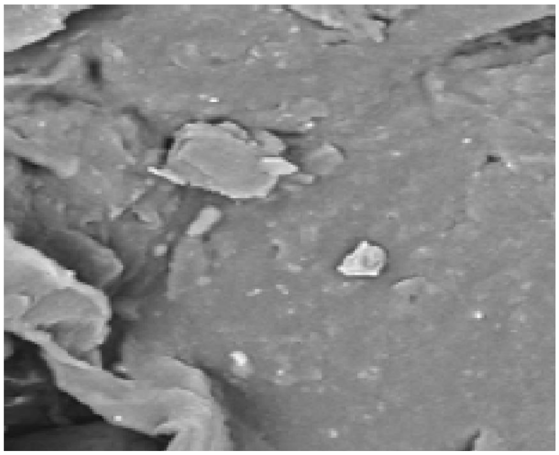
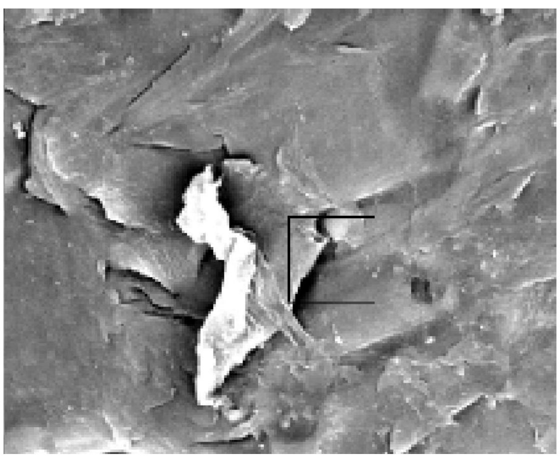
Morphological analysis using SEM clearly show difference in the morphology of the particleboard composites produced (see Figure 2). The microstructure clearly shows that when the agro-waste particle was added to the RLDPE resin, morphological change in the structure take place.



a) at 30wt RLDPE



b) at 60wt RLDPE

Figure 2 : SEM Microstructure of Maize cob/RLDPE particleboard

The agro-waste particles are embedded within the amorphous matrix composed of randomly distributed in the matrix planar boundaries. The surface of the agro-waste particles is smooth indicating that the compatibility between particles and the resin good[5, 8]. The values obtained for the thickness swelling(TS) and water absorption (WA) of the particleboards were moderate (see TABLE 1).

This is due to not using water repellent agents in the particleboard manufacturing. Agro-waste particles affected the WA and TS properties negatively. The similar results were found by Ntalos and Grigoriou[5]. In addition, wall thickness of particles was found to be within the ranges than that of common wood species[6].

The increase in modulus elasticity with increasing RLDPE resin addition is expected since the addition of resin to the agro-waste particles increases the stiffness of the particleboard composites(see TABLE 1). The presence of polar group in the resin may contribute to electrostatic adsorption between resin and the particles. This phenomenon is driven by different charges acting on resin or particles surfaces; which depend on particle's type, pH value or inter-medium[9]. This mechanism strengthen the board interface, hold them together and increase their resistance to deformation[3].

The MOR ranged from 7.89 to 12.05N/mm^2 (see TABLE 1). The MOR requirements of 11.5 N/mm^2 for general purpose boards by EN 312-2[10]. Particleboards made from 30wt% RLDPE had MOR lower than the requirement for general purpose. In addition increasing RLDPE Resin increased the MOR upto 50wt%. Beyond this level no further increased in MOR was obtain. The range of data of IB was from 0.45 to 0.60 N/mm^2 (see TABLE 1). The IB requirements of 0.24 N/ mm^2 for general purpose boards, 0.35 N/mm^2 for interior fitments, load-bearing boards and 0.50 N/ mm^2 for heavy duty load bearing boards by EN 312-2[10] respectively. The internal bond strength(IB) is comparable with values reported by[1]. Boards made from *maize cob* particles and RLDPE surpassed the

TABLE 1 : Properties of Maize cob and RLDPE particleboards

% of RLDPE	% of WA 2hrs	% of WA 24hrs	% of TS 24hrs	MOR(MPA)	MOE(MPA)	IB(MPA)	IM(Joules)
30	21.67	57.00	16.79	5.78	890.00	0.35	2.00
40	18.90	54.89	14.00	8.65	1000.00	0.45	3.50
50	17.75	52.00	13.00	10.67	1456.09	0.56	4.40
60	15.46	50.00	10.05	11.45	1567.00	0.58	4.70
70	14.89	48.90	9.79	10.64	1670.67	0.41	4.90

mechanical strength requirements for general purpose applications specified by European standard. In fact the strengths for the boards exceeded the requirements for load-bearing board for use in dry condition[6]. All of the particleboards produced are within the recommended standard i.e for general purpose, interior fitments, load-bearing boards and heavy-duty load bearing boards.

CONCLUSIONS

This present research is centred on the development and characterization of the microstructure and properties of particleboard composites using maize cob and RLDPE Resin. From the above results and discussion the following conclusions are made:

This work shows that successful fabrication particleboards can be made from maize cob particles and RLDPE Resin by simple compressive moulding technique

The uniform distribution of the particles and the resin in the microstructure of the boards composites is the major factor responsible for the improvement in the mechanical properties.

The developed particleboard composites can be use in density particleboards for general purpose requirements like panelling, ceiling, partitioning e.tc. in interior decoration since the properties of particleboard composites used in this area compared favorably with the properties of the developed board composites at 40-60wt%RLDPE Resin.

REFERENCES

[1] L.T.Chew, M.N.Nurulhuda, C.L.Ong, S.Rahim; Particleboard from Some Plantation Species. 708-724 in Abod SA et al.(Eds.) Proceedings of a Regional Symposium on Recent Developments in Tree Plantations of Humid/Subhumid Tropics of Asia, 5-9 June 1989, Serdang, Universiti Putra Malaysia, Serdang, **(1991)**.

[2] A.D.Hofstrand, A.A.Moslemi, J.F.Garcia; Forest Prod.J., **34(7)**, 57-61 **(1984)**.

[3] P.Khristova, N.Yussifou, S.Gabir, I.Glavche, Z.Osman; Cell.Chem.Technol., **32**, 327-337 **(1998)**.

[4] R.Kozlowski, M.Helwig; Lignocellulosic Polymer Composite, In: Prasad, P.N.(Ed.), Science and Technology of Polymers and Advanced Materials, Plenum Press, New York, 679-698 **(1998)**.

[5] G.A.Ntalos, A.H.Grigoriou; Industrial Crops and Products, **16(1)**, 59-68 **(2002)**.

[6] BSI, BS EN 312:2003: Particleboards, Specifications, The British Standards Institution, London, **(2003)**.

[7] ASTM E290, Physical Testing Standards and Mechanical Testing Standards, **(1990)**.

[8] M.Kuo, D.Adams, D.Myers, D.Curry, K.Heemstra, J.Smith, Y.Bian; Forest Prod.J., **48(2)**, 71-75 **(1998)**.

[9] Y.Yamashita, H.Watanabe, S.Takeda; Forest Research, **71**, 65-70 **(1999)**.

[10] EN 312-2, Particleboards-Specifications-Part 2: Requirements for General Purpose Boards for Use in Dry Conditions, European Standardization Committee, Brussell, **(1996)**.