J. Basic. Appl. Sci. Res., **1(12)2806-2810, 2011**

ISSN 2090-4304
Journal of Basic and Applied Scientific Research
www.textroad.com

Evaluation of the Mechanical Properties of Recycled Polyethylene/Iroko wood Saw Dust particulate Composite

***Atuanya, C.U. ** Nwigbo Solomon**

*Metallurgical and Materials Engineering department, Nnamdi Azikiwe University Awka.
**Mechanical Engineering Department, Nnamdi Azikiwe University Awka.

ABSTRACT

The objective of this study was to evaluate the Mechanical Properties of composite board manufactured from Recycled Low Density Polyethylene (RLDPE) and Iroko wood saw dust particulate. The Polyethylene used was harnessed from pulverized recycled table water sachets. The RLDPE and saw dust were properly mixed and injection molded at a pressure of 150MPa and temperature of 160^{o}C. The mechanical properties tests were carried out. The results obtained show that there is decreasing tensile strength value and impact strength as the saw dust loading increased in the RLDPE matrix. However the stiffness increased as the weight fraction of the saw increased. Hence Iroko saw dust can be used to improve the stiffness and hardness values of RLDPE composites.
KEY WORDS: Recycled Low Density Polyethylene, Composite, Injection Molding, Iroko Wood Saw Dust, Mechanical Properties.

INTRODUCTION

The field of natural fiber-reinforced thermoplastic composite materials is growing even in developing countries. The development has found importance industrial applications, domestic and academics. The term natural fibre covers a broad range of vegetable, animal and mineral fibre. Ecological and economic concerns are the major stimulating factors that fuel the rapid growth in this aspect of research (Yam, 1990).

One can easily equate once again the volume of work in this area with that of other synthetic fibers of carbon and glass. As the cost of plastics and timber get higher, there is a need to develop an alternative source (recycling of waste) as a substitute to the function they perform in engineering manufacture. (Atuanya & Nwigbo, 2008)

Waste recycling is an interesting approach to achieving an efficient integrated manner of managing municipal solid waste. Most recently, in Nigeria, government has become interested in this method of waste management. It is well observed that urbanization, industrialization and population growth in Nigeria has affected the solid waste generation. In major cities like Lagos, the poorly disposed solid waste has occupied most of the bus stops and drainages. It was estimated that up to 0.66 kg per capital per day; 255,556 tonnes per month of solid municipal wastes generation is possible in the city (Ogwueleka, 2009).

In Oyo town, Nigeria, up to 55.2 tonnes of solid waste is generated per year (Afon and Okewole 2007). In every one kg of refuse collected, it was quantified that up to 38% is made up of low density polyethylene product.

This is the major packaging material for food, drinking water and domestic materials purchased from stores and markets. Water packaged in this manner serve more than half the country's population. The saw dust is also creating some difficulties in the wood market all over the region where there is major wood processing. The most possible utilization of this material is in some cooking stoves where it is used as fuel. The unfortunate fact still remains that since the stove is not popular due to some reasons, most times the saw dust is disposed by burning and sometimes dumped at erosion sites. The major attraction to this research is the availability of the product (saw dust) and the matrix (polyethene) all year round. This discovery of the need for these wastes to serve as raw materials in an important sector of engineering manufacture has opened a new area of interest for research.

MATERIALS

The polyethylene (table water sachets) used in the study was waste low density polyethylene (LDPE) obtained from industrial waste of IBETO MG. (Ibeto Group of Companies Nig Ltd Nnewi, Nigeria). The wood

***Corresponding Author:** Atuanya, C.U., Metallurgical and Materials Engineering department, Nnamdi Azikiwe University Awka.
Email: Atueye2003@yahoo.co.uk

used was a hard wood saw dust collected from a local sawmill in the wood/timber market at Awka in Anambra State Nigeria.

Preparation of the Sample

The table water sachets were sliced and reduced to small sizes by a pulverizing machine with the help of two rotating knives designed and fabricated in house. The wood sawdust was dried for 24 hours in the sun; thereafter the sawdust was sieved using 18 mesh sieve size and later dried in an oven at $110^{o}C$. With this process, the moisture content was reduced to 3.0%.

Composite Processing

The saw dust was varied from 10% to 35% in the RLDPE matrix. Mixing of the composite components was performed manually, physically in a bowl. Then the mix was fed into an injection moulding machine of the reciprocating screw type in Olikeze Company, Nigeria. The temperature was set at $160^{0}C$ and a pressure of 150MPa. The mould was designed to obtain flat boards/panels.

Testing

Prior to testing, the samples were conditioned at $23^{o}C$ and 65% relative humidity. The tests were carried out to assess the influence of the hardwood sawdust on the mechanical performance of the polyethylene in the wood sawdust-RLDPE composites. The specimens in each instance were tested at room temperature and the test conditions were according to relative ASTM standards (ASTM D 638-99, 2000).

Tensile tests were carried out using Instron Testing Machine, in accordance with ASTM 638-99, at a cross-head speed of 100mm/min (ASTM D 638-99, 2000). The specimens were pulled till failure and the respective loads and extensions were noted. The values thus gathered were used to calculate the strain, the tensile strengths, and modulus of the specimens.

Flexural test was carried out at Standard Organization of Nigeria in Enugu, in accordance with standards of ASTM 790-90(Harish et al, 2009). The three-point bending test was carried out to obtain the flexural strengths and modulus of the specimens using the appropriate conversions and mathematical equations.

Hardness tests were carried out on all specimens at Standard Organization of Nigeria. Brinell Hardness test was conducted using a manually operated universal testing machine. The indentations on the specimen were measured (diameter-wise) and appropriate mathematical methods used for conversion to obtain the Brinell Hardness values.

Impact energy test were conducted on all specimen according to ASTM standards D 256-90(Harish et al, 2009). Specimens prepared were subjected to fracture by a pendulum-type Impact Testing Machine. The toughness values of the composites obtained by reading off the energy expended to rupture the specimens.

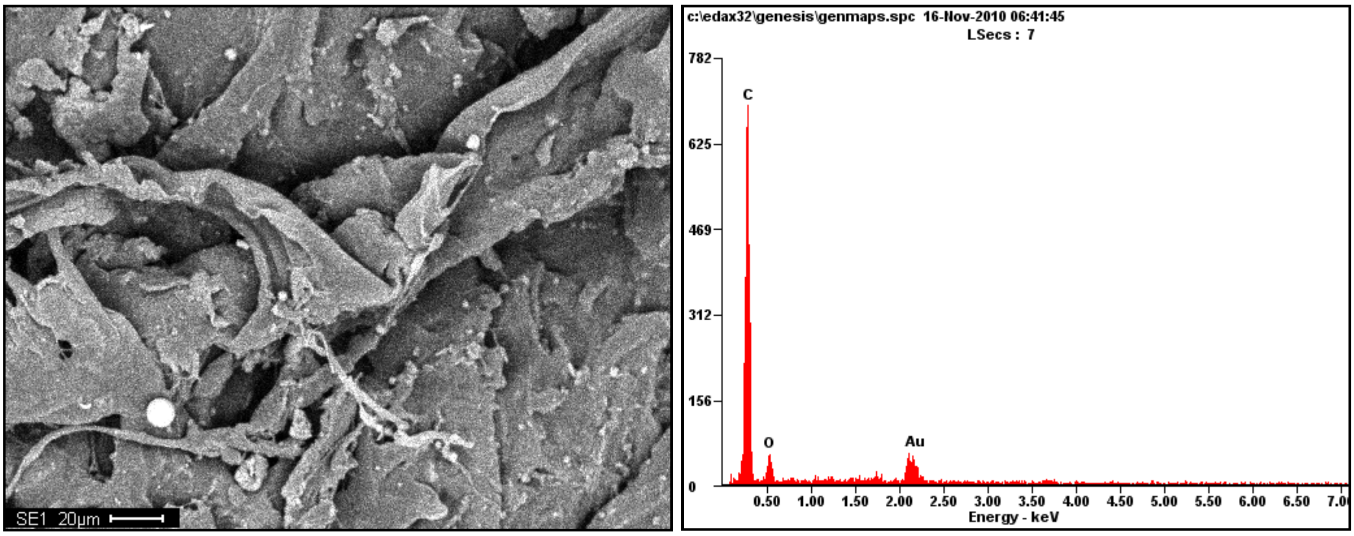
Scanning Electron Microscopy (SEM) with JEOL JSM-6480LV was performed on the sample with 30% wood sawdust (Harish et al, 2009).

RESULTS AND DISCUSSION

The SEM microstructure reveals that there are small discontinuities and a reasonably uniform distribution of saw dust particles in the RLDPE matrix. The ceramic phase is shown as white phase, while the polymer phase is dark. The saw dust particles are embedded within the amorphous matrix composed of randomly distributed in the matrix planar boundaries.

The surface of the saw dust particles is not smooth indicating that the compatibility between saw dust particles and RLDPE matrices is poor. It can be seen that the saw dust particles are detached from the resin surface. This is due to poor interfacial bonding between the RLDPE matrix and the saw dust particles (Harish et al ,2009).

The EDS analysis shows that there are no chemical reactions within the composite. The blending of the wood particles with the RLDPE did not spark off any chemical reaction. The most likely reason for this was the careful control of the operating temperature as it was kept low enough. The major elements revealed by the EDS are carbon and oxygen. These of course are the major functional groups expected to be present in a wood particle (see Micrograph 1).



Micrograph 1: SEM/EDS of Composites produced with 30% sawdust

Figure 1 and Table , shows the effect of hardwood sawdust on the tensile and flexural strengths of the wood flour RLDPE composite.

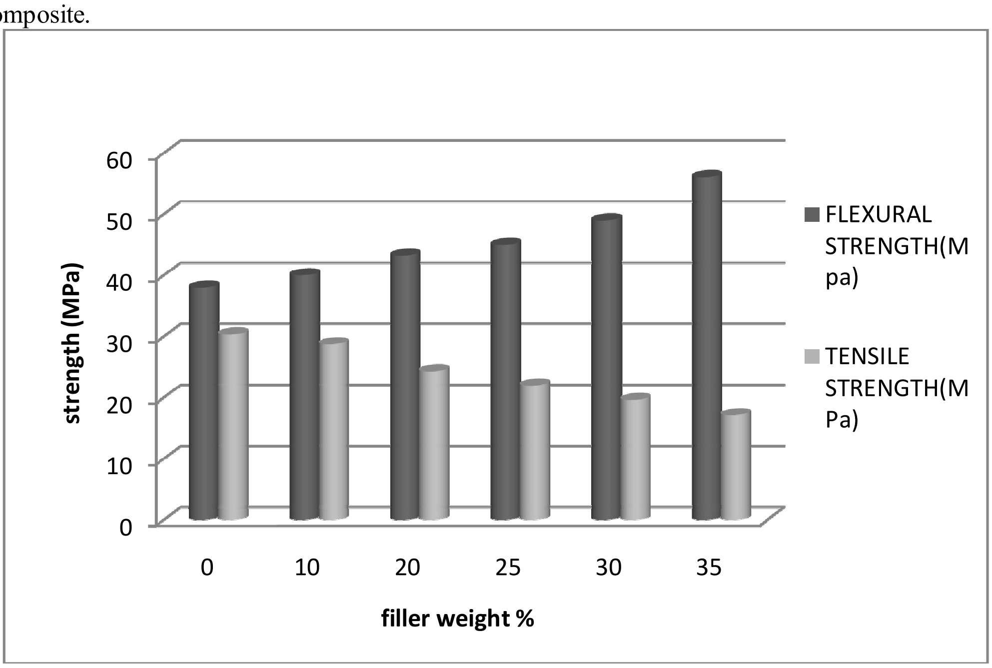


Figure 1. The graph of material Strength against filler content.

The tensile strength of wood composites decreased slightly as the sawdust loading increased, however the composite retained acceptable level of strength (Jacquemin et al, 2009). As the saw dust loading increased, the poor interfacial bonding between the reinforcer and the matrix polymer caused the tensile strength of the composite to reduce. The slightly decreased in tensile strength may also be attributed to increase in the interfacial area as the particles content increased, which resulted in worsening the interfacial bonding between the particles(hydrophilic) and matrix polymer(hydrophobic) (Micrographs 1). Also the reduction in tensile strength may be due to agglomeration of the filler particles in the RLDPE matrix which form a domain that look like a foreign body in the matrix or simply the result of physical contact between adjacent aggregates (Sreekala et al, 2000). Since there was a high amount of agglomerates in higher reinforce loading composites, these agglomerates act as obstacles to chains movement and initiate failure under stress. Agglomerates will become stress concentrator and building up stresses in composites quicker than usual and caused earlier rupture if compared to unfilled samples. This observation is in line with the earlier work of Zani, et al (1995).

The Impact strength decreased with increased in the saw dust loading due to increase in size of the poor bonded area between the hydrophilic reinforcer and the hydrophobic matrix polymer. The steep reduction in the impact energy of the composites could be attributed to the presence of particle clusters and weight fraction of second phase particles. These factors contribute to decrease in weight fraction of the ductile phase (weight fraction of the matrix phase) and there by leads to decrease in impact energy, also it is obvious that plastic deformation of the mixed polymer matrix and the non-deformable reinforcement is more difficult than the polymer matrix. These results are in agreement with the work of other researchers (Khalid et al, 1998, Mohanty et al, 2002, Mishra et al, 2002). This situation could be easily confirmed from the corresponding gradual decrease in the mean value of percentage elongation at break. This is therefore, a tradeoff between stiffness and brittleness of the composite.

The flexural modulus increased linearly with increasing sawdust content. It is a common knowledge that the addition of reinforcer to thermoplastics increases the modulus (see Figure 2 and Table 1).

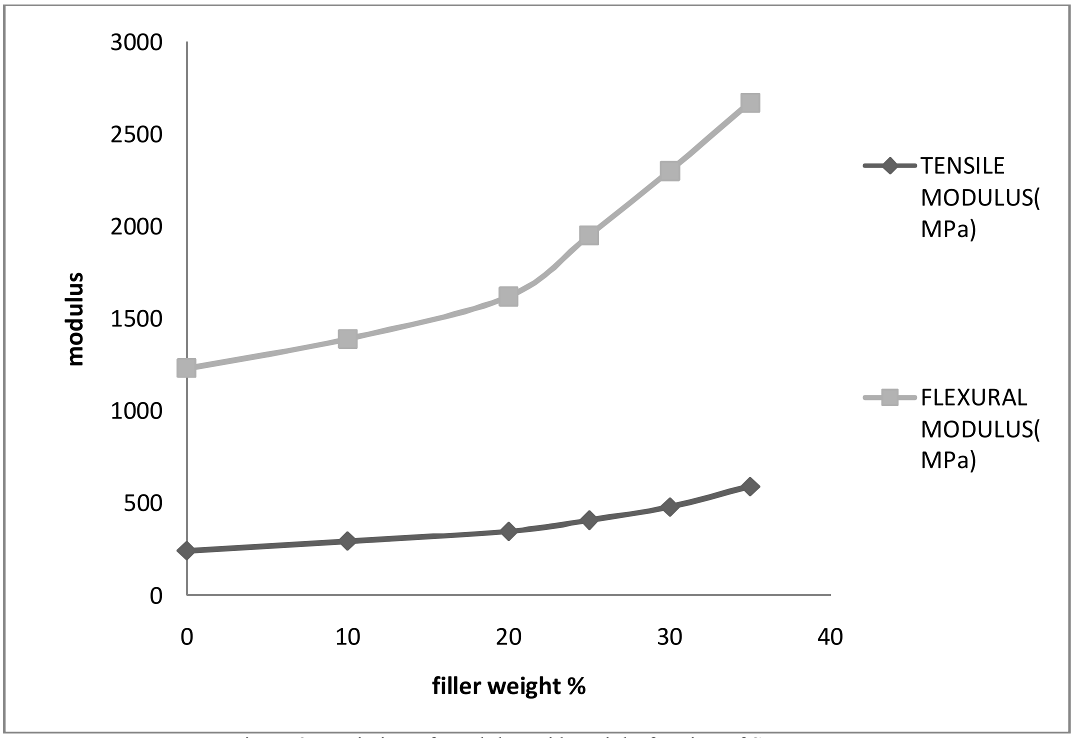


Figure 2: Variation of Modulus with weight fraction of Saw Dust

The increase in Young's modulus with increasing sawdust loading is expected since the addition of reinforcer increases the stiffness of the composites, which in turn decreases the elongation at break. Also the increase of modulus may be attributed to the ability of filler in fibrous form to carry more tensile load (Thwe and Liao, 2000). This mechanism will strengthen the polymer-fiber interface. It will hold them together and increase their resistance to deformation. This has been observed somewhere with oil Palm wood flour (Zani, et-al 1995). Maximum flexural strength exhibited the same trend the flexural modulus and tensile modulus.

TABLE 1. COMPILED COMPOSITE PERFORMANCE.

SPECIMENN PROPERTY	UNIT						
FILLER WT	%	0	10	20	25	30	35
ELLONGATION AT BREAK	%	12.6	9.8	7.0	5.4	4.1	2.9
TENSILE STRENGTH	MPa	30.33	28.73	24.25	21.97	19.61	17.12
FLEXURAL STRENGTH	MPa	38.00	40.00	43.2	45.00	49.00	56.10
UNNOTCHED IMPACT	J/m	-------	440	375	315	287	213
BRINELL HARDNESS NO	------	2.3	3.1	3.8	4.3	4.4	4.5

Specimen dimension for tensile test=150x3mm

Table 1 shows the hardness values of both the unreinforced and reinforced RLDPE composites. From the Table 1, the hardness values of the composite samples increased as the percentage saw dust particles addition increased in the RLDPE matrix. In comparison with the unreinforced RLDPE matrix, a substantial improvement in hardness values was obtained in the reinforced polymer matrix. This is line with the earlier research of (Kandachar and Brouwer, 2002, Harish et al, 200).

Conclusions

From the above results and discussion the following conclusions are made:

1. That successful fabrication of Iroko wood saw dust particles reinforced RLDPE composites by injection moulding technique was achievable.
2. The impact strength of the composites slightly decreased with increase in saw dust particles addition.
3. The tensile properties obtained are in agreement with the results obtained from the analysis of the hardness and impact strength.
4. Flexural strength increases with increase in saw dust particles in the RLDPE matrix.

REFERENCES

Abel O Afon and Afolabi Okewole (2007), Estimating the Quantity of Solid Waste Generated in Oyo, Nigeria. Waste Management and research. Vol 25 (4) pp 371-379.

Atuanya C.U and Nwigbo S.C.(2008). The Effect of Filler Content Size on the Mechanical Properties of Unsaturated Polyester/Cocoanut Empty Fruit Shell and Fibre Composite, Journal of Engineering and Applied Science 4:2-3.

American Society for Testing and Materials (ASTM), 2000. ASTM D 638-99-2000 and 790-99-2000. ASTM Committee on Standards. West Conshocken, PA, pp. 1- 13 and 145-151.

Harish S, Michael D. P, Bansely A, Mohan Lal D. and Rajadurai A, (2009), “Mechanical property evaluation of natural fiber coir composite”, Materials characterization, 60, 44-49.

Jacquemin. F, Freour .S, Guillen .R(2009), Prediction of local hygroscopic stresses for composite structures- Analytical and numerical micro- mechanical approaches, Composites Science and Technology 69, 17–21

Khalid A.A, Sahari .B, Khalid .Y.A(1998) Environmental Effects on the Progressive Crushing of Cotton and Glass Fibre/Epoxy Composite Cones. In: Proceedings of the Fourth International Conference on Advances in Materials and Processing Technologies, 98, Kuala Lumpur; 680–689.

Kandachar P, Brouwer R(2002) Applications of bio-composites in industrial products. Mater Res Soc Symp Proc; 702: 101- 12.

Thew, M. M, Liao, K. (2002) Effect of environmental aging on the mechanical properties of bamboo-glass fiber reinforced polymer matrix hybrid composites. Compos Part A. 33:43-52

Mishra, S., M. Misra, S.S. Tripathy, S.K. Nayak and A.K. Mohanty(2002): The influence of chemical surface modification on the performance of sisal- polyester biocomposites. Polymer Composites 23(2):164-170.

Mohanty AK, Misra M, Drzal LT(2002) Sustainable bio-composites from renewable resources: opportunity and challenges in the green materials world. J Polym Environ ;10:19–26

Ogwueleka, T.Ch.(2009): Municipal Waste Characteristics and Management in Nigeria. Iran Journal of Environmental health Science. 6.3. 173-180.

Sreekala, M.S., M.G. Kumaran, S. Joseph, M. Jacob and S. Thomas(2000). Oil palm fiber reinforced phenol formaldehyde composites: influence of fiber surface modifications on the mechanical performance. Applied Composite Materials 7:295-329.

Yam, K. (1990): Composites from Compounding Wood Fibers with Recycled High Density Polyethylene. Polymer Eng. Sci. 30: 693.

Zaini, M.J, Fuad,M.Y.A, Ismail,Z, Mansor,M.S and Mustaphah,J. (1995):“The Effect of Filler Content and Size on the Mechanical Properties of Polypropylene/Oil Palm Wood Flour Composites. Polymer International. 0959-8103/96