ASSESSMENT OF BAGASSE AND PERIWINKLE SHELL ASH REINFORCED POLYMER MATRIX COMPOSITE FOR PARTICLE BOARD PRODUCTION

BY

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A DISSERTATION SUBMITTED TO THE DEPARTMENT OF MECHANICAL ENGINEERING, FACULTYOF ENGINEERING, BAYERO UNIVERSITY, KANO,IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF THE DEGREE OF MASTERS OF PRODUCTION ENGINEERING

DECEMBER, 2015

DECLARATION

I hereby declare that this work is the product of my research efforts undertaken under the supervision of Dr. Ibrahim Abdullahi and has not been presented anywhere for the award of M. Engr.degree. All sources have been duly acknowledged.

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CERTIFICATION

This is to certify that the research work for this dissertation and the preparation of the dissertation and the subsequentwrite-up by SYLVESTER, GOJIM SARA(SPS/11/MPE/00004) were carried out under my supervision.

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ACKNOWLEDGEMENT

I wish to acknowledge the Lord God Almighty for His love and kindness to me and for being the source of my strength and seeing me through this period of studies.

It would take some pages to name or acknowledge all who rendered assistance to me in one way or the other for this piece of work to come out well. However only some of the names of people who contributed towards this success are mentioned.

I wish to express my heartfelt appreciation to my supervisor Dr. Ibrahim Abdullahi whose helpful suggestions and tedious supervision made this work possible. I cherished his detailed reading of all materials submitted to him. This has indeed rekindled my interest in academic work which I left over twenty years ago. I have learnt under him to carry out independent study indeed. I once more appreciate his effort.

I am grateful to the Head of Department of Mechanical Engineering Department of Bayero University, Kano and the academic staff of the department particularly Prof. A.T. Abdullahi, Prof. A.Salihi, Prof. A.U. Alhaji, Prof. I.Rufai and Dr. M. Makoyo for their support during the course work and the writing of the dissertation. I particularly appreciate the support of the workshop/Laboratory staff during the period of carrying out the various tests especially Mallam Mustapha. Other staff members of the department are also duly acknowledged for their unflinching support.

I wish to also express my appreciation to the management of the Nigerian Geological Survey Agency, Kaduna and the National Institute of Leather and Science Technology, Zaria for allowing me to use some of their facilities and equipment in carrying out the research tests. The support of their workshop/laboratory staff members is highly acknowledged.

I am indebted to my family, the Minister and members of Assemblies of God Church, Mando-Kaduna, the Minister and members of Beauty for Ashes of Ibrahim Taiwo road, Kadunafor their support and prayers.

The management of the National Water Resources Institute (NWRI), Kaduna is highly appreciated for the official permission granted me to undergo the Postgraduate Studies at Bayero University, Kano.I equally wish to appreciate my colleagues at the National Water Resources Institute, Kaduna for their moral support and encouragement.

My special thank goes to my colleagues and classmates especially VerorFaeren, Musa Hassan and Umar Adam. Umar J. Adam in particular has been of great help to me in this dissertation. I thank you very much and wishing you all the best in all your life endeavors.

DEDICATION

This project is dedicated to my beloved wife Mrs. Charity G. Sara and children David R. Sara, Joshua N. Sara and Mercy N. Sara.

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DEFINITION OF TERMS

SYMBOL	DESCRIPTION
PE	Polyethylene
PWK	Periwinkle shell
BA	Bagasse
MOR	Modulus of Rupture
MOE	Modulus of Elasticity
UTS	Ultimate Tensile Strength
El	Percentage elongation
WA	Water Absorption
TS	Thickness Swelling
ASTM	American Standard of Testing Materials
EN	Emergency Number for Estonian republic standard

ANSI American National Standard Institute

m_f mass of fiber

$m_c$mass of composite

M_FMass Fraction

ABSTRACT

Composites based on natural fibre reinforcement have generated wide research and engineering interest in the last few decades. In this work, an assessment of Bagasse and Periwinkle Shells Ash as a Composite Material for Particle Board Production was carried out. The weight of the reinforcement were varied in accordance with these values: 5g, 10g. 15g, 20g.The process involves grinding of the materials, sieving, weighing, compounding and pressing. Physical tests (density, water absorption, and thickness swelling) and mechanical properties tests(modulus of rupture, modulus of elasticity, and ultimate tensile strength) were carried out. The results of the mechanical tests showed high Modulus of rupture (MOR) of 25.80 MPa, Modulus of Elasticity (MOE) of 108.81MPa, Ultimate Tensile Strength (UTS) of 9.32MPa, and Percentage Elongation(El)of 63.39 % for periwinkle shell ash plastic composite; 25.93 MPa for MOR , 38.45MPa for MOE, 5.76MPa for UTS, and 59.85 % for El for bagasse plastic composite; and MOR of 19.00 MPa , MOE of 62.28 MPa, UTS of 7.54MPa, and El of 47.48% for the periwinkle shell bagasse plastic hybrid composite. From the results obtained, it was found that the developed composite has good filler characteristic at 10wt% fibre and so can be used for the production of Ceiling Boards.

CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND OF THE STUDY

When two or more materials combine together to form a different material, which have different properties: texture, microstructure and any other mechanical or chemical properties among others, definitely its weight, moisture content and thermal conductivity will vary from any of the parent material. The combined material can either be an alloy or composite. Either of these materials (alloy or composite) is a combination of two or more materials which the resulting material's properties (both mechanical and physical) differ from that of the constituents materials (Agbanigo and Alawode, 2008).It is because no material in nature possesses all the good properties of engineering materials that alloys and composites have been developed (Agbanigo and Alawode,2008).

The demand for wood as a raw material in the forest industry has been on the increase, and the production of industrial wood from the natural forests cannot meet the demand as such leading to the continuous decline of wood production. The reduction in forest resources in developing countries is as a result of the depletion of the resources. However the decline in developed countries may be due to the withdrawal of forest areas for industrial production and for other uses such as recreational areas. In addition, there is a significant pressure on standing forest resources as a result of higher demand for wood due to the increasing population and new application areas. Consequently, there is a need for alternative resources to substitute wood raw material (Chew et al, 1991).

1.2 STATEMENT OF THE PROBLEM

The heavy burden of deforestation and regeneration created by the decrease in available supplies of solid wood in the production of particleboard gave birth to the idea of recycling agricultural waste product (Hofstrand et al, 1984, and Ives, 2001). Deforestation is becoming high making the vegetative cover so low which affect the community and cause environmental degradation. Also, the rampant disposal of bagasse mostly in the Northern part of Nigeria and periwinkle shells in the Southern part of Nigeria causes environmental pollution (Omoniyi and Olorunnisola, 2014). The indiscriminate disposal of low density polyethylene sachets has continued to constitute environmental damage to the surroundings. Even where these wastes are burnt, they still result in pollution which is affecting the environment negatively. These materials are all day-to-day wastes released to the environment continuously as commercial activities involving them increase in the country. Thus making use of these wastes will reduce the rate of environmental degradation. As these wastes are turned into useful materials, they may support the achievement of a cleaner, safer and an eco-friendly environment.

1.3 AIM AND OBJECTIVES OF THE RESEARCH

The aim of this research work is to assess bagasse and periwinkle shell ash as reinforcement in polymer matrix composite materials for particleboard production.

The specific objectives of this research are as follows:

i. To develop a plastic composite using bagasse and periwinkle shell as reinforcement.
ii. To evaluate theproperties(density,water absorption, thickness swelling, tensile strength, and flexural strength) of the developed composites in order to determine their suitability for particle board production

iii. To compare the results with that of standard particle board

1.4 METHODOLOGY

Some of the methods employed in conducting this research are:

I. Review of composite materials and binding agents.
II. Collection and preparation of bagasse and periwinkle shell for composite production
III. Developing the composites
IV. Evaluation of the composites.
V. Conclusion and recommendations on the developed composites

1.5 SIGNIFICANCE OF THE RESEARCH

The significance of this research includes:

i. It will serve as alternative material for the production of particle board.

ii. It will add economic value to the abundant polyethylene water sachets, bagasse and periwinkle shells in Nigeria.

1.6 SCOPE AND LIMITATION OF THE STUDY

This research work is limited to the production and property evaluation of particle board using bagasse and periwinkle shell ash as reinforcement and recycled polyethylene as a matrix or binding agent.

CHAPTER TWO

LITERATURE REVIEW

2.1 COMPOSITES

Most present day engineering materials are expected to be light weight, corrosion resistant, and to have high strength. Since no material in nature possesses all these properties, alloys and composites have been developed (Agbanigo and Alawode, 2008). A composite material can be defined as a combination of two or more materials that results in better properties than those of the individual components used alone. In contrast to metallic alloys, each material retains its separate chemical, physical, and mechanical properties. The components of a composite can be metals only or metal in combination with non-metals like polymers or non-metals only (Agbanigo and Alawode, 2008). There are two main types of non-metallic composites namely thermoset composites and thermoplastic composites.The methods of manufacturing these composites include injection moulding, compression moulding, liquid moulding, lay-up, thermoforming, filament winding, spray-up and pultrusion. The main advantages of composites are their high strength and stiffness, combined with low density, when compared with bulk materials, allowing for a weight reduction in the finished part.

Natural composites exist in both animals and plants. Wood is a composite made from long cellulose fibres (polymer) held together by a much weaker substance called lignin. The bone in our body is also a composite made from a hard but brittle material which is mainly calcium phosphate and a soft and flexible material called collagen. People have been making composite for years. One early example is the mud bricks with straw. Another ancient composite is concrete. The lack of resistance to overcome tensile strength by concrete is achieved by providing steel bars at appropriate places resulting in a composite structure called reinforced concrete (Agbede and Monash, 2009).

Most composites are made up of just two materials. One is the matrix or binder which surrounds and binds together fibres or fragments of the other material which is called the reinforcement (Aigbodion et al, 2011).

The combinations of two composites result in the formation of hybrid composites. Hybrid composites possess better properties compared with single reinforced composites as they combine the advantages of their constituent reinforcements (Thakur et al, 2012).

2.2 SUGARCANE BAGASSE

Sugarcane belongs to the grass family which includes sorghum and corn. It has been known in New Guinea since 6000BC and due to human migration, it spread to Southeast Asia, the Pacific, Egypt, Syria, Greece and Spain followed by introduction to West Africa and subsequently Central and South America and lastly the West Indies (Anon.2007b). It is an established agricultural field crop with a long history of safe use. It is primarily grown as a source of sugar even though in Nigeria and West Africa most of the juice is consumed locally. Several by-products are produced from sugarcane at the sugar mill. These primarily include bagasse (fibre) and molasses. Bagasse (chaff) is the fibrous portion of sugarcane that remains after the juice has been removed. It is used to make paper and animal feed, and also in the production of biofuels. It has also been shown to be an effective bio- solvent with great potential for its use in waste management (Anon.2007b). It can also be burnt to produce steam as a source of power. However in Nigeria, bagasse is left as wastes in various places. Among the many agricultural fibres used for paper and board manufacture, bagasse is the one with most promise and is easily accessible and readily available in many countries (Chandra, 1998).

Usman et al(2014) carried out chemical analysis of bagasse and the result is shown in Table 2.1.

Table 2.1- Composition of Bagasse ash(Nigerian specie– Savanah Sugar Company Numan)

Constituents	**% Weight**
Silicon Oxide	76.168
Aluminium Oxide	11.079
Iron Oxide	3.700
Calcium Oxide	2.521
Sodium Oxide	0.379
Potassium Oxide	3. 498
Magnesium Oxide	1.455
Sulphur Oxide	0.701
Loss of ignition	3.580

Filho Toledo et al, 2004 also carried out the chemical composition of sugarcane bagasse (Brazilian specie) and found it to be similar.

Bagasse is processed in special machine in two stages, dried, mixed with a binder, and hot pressed in the same way as boards made from wood particles. The boards produced ranged in thickness from 8-35mm, and in density from 0.30-0.75g/cm$^{3.}$ Strength properties are comparable to those of similar boards made of jute sticks and various wood species. Bagasse particleboards can be used as flooring, wall partitions, ceilings roofing and furniture. (Hesch, 1967)

Nilza et al, (2007) used three Jamaican natural cellulosic fibres for the design and manufacture of composite material. They took bagasse from sugar cane, banana trunk from banana plant and coconut coir from the coconut husk. Samples were subjected to standardized test such as ash and carbon content, water absorption, moisture content, tensile strength, elemental analysis and chemical analysis.

2.3 PERIWINKLE SHELL

It is a waste product got from the consumption of small marine snail (periwinkle) which is housed in a v-shaped spiral shell and is found in many coastal communities in Nigeria. It is also available in many coastal areas worldwide and is very strong, hard and brittle material. Stretching from the Niger Delta between Calabar in the East and Badagry in the Western part of Nigeria, the people in these areas take the edible part as sea food and dispose of the shell as waste product, though a few persons use the shell as coarse aggregate in concrete in places where there are neither stones nor granite for such purposes (Olutogeet al, 2012). There are however, large amount of these shells being disposed of as waste thus constituting environmental problems in places where use cannot be found for them. In some of the places, large deposits have accumulated over the years. Olutogeet al, 2012 carried out chemical analysis of Periwinkle Shell Ash (PSA) and the result is shown in Table 2.2

Table 2.2: Chemical Analysis of Periwinkle Shell Ash

Constituents	**% Weight**
Zinc Oxide	5.31
Copper Oxide	7.45
Iron Oxide	1.75
Manganese Oxide	0. 57
Magnesium Oxide	8.98
Silicon Oxide	3.56
Aluminium Oxide	2.28
Potassium Oxide	5.90
Calcium Oxide	44. 26
Sodium Oxide	1.41
loss on Ignition	10.38
Others	8.45

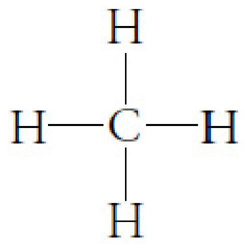
(Adapted from Olutoge F.A.etal, 2012)

Aku et al, 2012 also carried out chemical composition analysis of periwinkle shell particle and got similar result.

It has been investigated that periwinkle shell and rice husk ash using cashew nut as the matrix binder will serve better in the production of composite which indeed is a way of reducing of environmental pollution as well as adding value to the economy. The test conducted showed that the compressive strength of the periwinkle shell ranged between $14.8N/m^2$ and $35.4N/m^2$ and that it will be able to replace granite for a concrete ratios of 1:2:4 and 1:3:6(Michael et al, 2011). It will result in having a saving of 14.8% and 17.5% respectively in concrete mixture. The mechanical properties of the composite increased with increased in the filler content (Michael et al, 2011).

2.4 POLYMER

Low-density polyethylene *(LDPE)* ($0.910\ g/cm^3 <$ density $< 0.925 g/cm^3$) is a thermoplastic material composed of carbon and hydrogen atoms joined together forming high molecular weight products as shown in Figure 2.1 c. Methane gas (Fig. 2.1 a) is converted into ethylene (Fig. 2.1 b), then converted, with the application of heat and pressure, into polyethylene (Fig. 2.1 c). The “Pure Water” sachet belong to this low density polyethylene. The polymer chain may comprise of 500,000 to 1,000,000 carbon units. Short and/or long side chain molecules exist with the polymer’s long main chain molecules. The longer the main chain, the greater the number of atoms, and consequently, the greater the molecular weight and that the molecular weight distribution and the amount of branching determine many of the mechanical and chemical properties of the end product of a substance (Lester, 1999) and the formation of polyethylene shown in Fig 2.1a – 2.1c



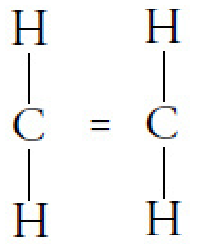


Fig 2.1a Methane gas Fig 2.1b Ethylene

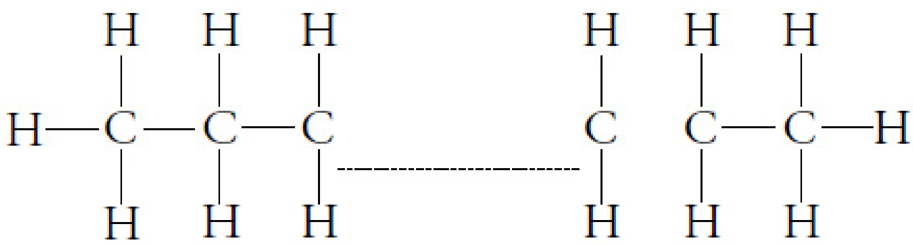


Fig 2.1c Polyethylene

Fig. 2.1: Structure of Polyethylene Formation (Lester, 1999)

Other common polyethylene (PE) materials arehigh-density polyethylene *(HDPE)* ($0.941 g/cm^3 <$ density $< 0.965 g/cm^3$) medium-density polyethylene *(MDPE)* ($0.926 g/cm^3 <$ density $< 0.940 g/cm^3$) used for low-pressure gas pipelines andLinear low-density polyethylene *(LLDPE)* which retains much of the strengthof HDPE and the flexibility of LDPE. Lesscommon PE materials are ultra-high molecular weight polyethylene (UHMWPE)(density $> 0.965 g/cm^3$) and very low density polyethylene (VLDPE) (density < 0.910).Other thermoplastic materials used for drainage pipes are polyvinyl chloride (PVC),polypropylene (PP), polybutylene (PB) and acrylonitrile-butadiene-styrene (ABS). (Lester, 1999)

A study carried out on materials used in automobile manufacture - current state and perspectives by Wilhelm, (1993) showed that the use of polymer in German automotive industries increases from 11%, within 1980-1990 to 15% within 1995-2000. Other materials, like aluminium also find more applications within the period while the use of steel and cast iron decreases from 69% to 60%. This shows that the use of polymer for parts production in automobile is on an increasing trend as it was forecast to have larger percentage in the recent years

Erica et al, (2008) carried out studies on materials choice in automotive bodies where both composite and Aluminium alternatives were considered. Steel was noted to be the most cost-effective option at the production volumes which is found in majority of vehicle models. Another study was carried out where composites were found to have significant economic potential when considering emerging advances of polymer composite in body design as compared to mild-grade steel body obtainable now (Johnson, 2009). Polymer composites used for body of vehicles, including their bumpers, makes them light-weight and thereby improves their fuel efficiency. According to the results, composite technologies hold not only the potential to reduce vehicle mass, but also do so in a cost-effective manner. This economic advantage, however, is strongly dependent on production volume (Erica et al, 2008)

Small, fuel efficient passenger vehicles generally contain more composites relative to their total weight than do larger vehicles, but larger vehicles such as minivans contain more composites by weight. (Demmler, 1998)

Composites provide a wide range of potential automotive applications—body panels, suspension, steering, brakes, bumper, and other accessories, where the demand varies widely by application. The application of composites is still predominantly in non-structural elements of the vehicle today, and is mostly glass fiber-reinforced thermoset polymers used in niche-market vehicles with annual production volumes of less than 80,000 (Millerschin,1999).

Out of 1998's total body panel market, composites enjoyed a share of 6%, aluminium 3%, and steel 91% in terms of total material consumption (Demmler, 1999). Some existing specific composite applications include fenders of the GMT 800 Chevrolet Silverado and F- 350, and as cowl in Toyota Sienna. Ford is using a glass-fiber composite for a one-piece cargo area for its Explorer Sport Track SUV/PU hybrid (Defosse, 1999).

2.5 POLYMER MATRIX COMPOSITES

Most commonly used matrix materials are polymeric. In general, the mechanical properties of polymers are inadequate for many structural purposes, particularly: their strength and stiffness are low as compared to that of metals and ceramics. These difficulties are overcome by reinforcing them with other materials. The reason for their common use is that the processing of polymer matrix composites does not involve high pressure and temperature. In addition, equipment required for manufacturing polymer matrix composites are simpler in operation and structure. For these reasons, polymer matrix composites have developed rapidly and have become popular for structural applications (Kopeliovich, 2010).

There are two types of polymer composite (Kopeliovich, 2010)

a. Fibres reinforced polymer(FRP)
b. Particle reinforced polymer(PRP)

2.5.1 Fibres reinforced polymer

Fibres reinforced composite contain fibres and polymer matrix. Fibres are the reinforcement and the main source of strength while matrix glues all the fibres together in shape and transfer stresses between the reinforcing fibres. The fibres carry the loads along their longitudinal directions. Sometimes, fillers might be added to smooth the manufacturing process, impact special properties, and/ or reduce the product cost.

Common fibre reinforcements include asbestos, carbon/graphite fibres, beryllium, beryllium carbide, beryllium oxide, molybdenum, aluminium oxide, glass fibres, polyamide, natural fibres etc. Similarly, common matrix materials include polythene, epoxy, phenolic, polyester, polyurethane, polyether ketone, vinyl ester etc. Among these resin materials, polyether ketone is widely used. Epoxy, which has higher adhesion and less shrinkage than polyether ketone comes in second for its high cost. (Kopeliovich, 2010)

2.5.2 Particles reinforced polymer

Particles used for reinforcement include ceramics and glasses such as small mineral particles, metal particles such as aluminium, amorphous materials and carbon black. Particles are also used to increase the modulus of rigidity of the matrix and to decrease its ductility. Particles are also used in order to reduce the cost of the composites. Reinforcements and matrices can be common inexpensive materials which are easily processed. An example of particle-reinforced composites is an automobile tire, which has carbon black particles in a matrix of poly-isobutylene elastomeric polymer (Kopeliovich, 2010).

2.6 STANDARD PARTICLE BOARD.

Particleboard also called chipboard is an engineered wood made product manufactured from materials in the form of discrete wood fragments and a synthetic adhesive (binder) which is then bonded together under heat or pressure (Bowyer et al., 2007). It is a composite product made under elevated pressure and temperature from particles of wood or other liqnocellulosic fibrous materials and a binder (EN312:2003). Particleboard is widely used in furniture, where it is generally overlaid with other materials for decorative purposes. It is the principal material used in ready-made and ready to assemble furniture, flooring systems, fabricated houses, and underlayment. As most applications of particleboards are interior, they are usually bonded with a urea-formaldehyde resin (Stark et al, 2010). In the European Union, formaldehyde is considered a high priority pollutant and is released when the products (particleboards) are new and when indoor temperatures or humidity are high (Fernandez Garcia et al, 2012). Formaldehyde is considered a probable human carcinogen and inhalation of even small amounts of the gas can increase risks of cancer (Anonymous, 2001). Presently, there is much interest in developing more environmentally friendly adhesives and many researchers have investigated the use of natural polymers obtained from plants and animals (Thakur et al, 2012). There is now need to utilize agricultural residues as raw materials for particleboard production. Use of these materials can divert wastes from landfilling or burning. These alternative materials include straw residue which is the stem of a grain crop such as rice or wheat, and bagasse, the residue from sugarcane processing. It should be noted that the amount of agricultural waste fiber far exceeds present and future fiber requirements for production of particle board and medium density fibreboard. Most residual straw and bagasse is now burned, which contributes to air pollution and global warming. Dry wood particles are sprayed with a binder resin, blended and then formed into a loose sheet that is further pressed under heat at high temperatures resulting in bonding of wood particles. The addition of the binder resin provides the entire inter-particle bond (Wechsler and Hizirogln, 2007)

The particleboard manufacturing process typically begins with the preparation of the raw materials which is always in the form of chips, saw dust or planar shavings. At the mill, logs are debarked first, sawn into smaller chunks and then committed into long and thin consistently sized particles using hammer mills, flakers or refiners (Wechsler and Hizirogln, 2007)

Standard Particleboard is the basic type of particle board product available or in use. It is not appropriate for external use or even in interior areas where wetting or prolong high humidity conditions exist. The binding agent used for standard particle board is urea formaldehyde and most often paraffin wax is added to the surface layers to provide protection against accidental water spillage. These particleboards are produced in the following thicknesses:9, 12,15, 16,16.5,18,20,22,25,28,30, 33, and 4 3 mm according to Australian Standard/ New Zealand Standard (AS/NZS 1859:2005). The thicknesses of the standard particle board according to Japanese Industrial Standard (JIS A 5908: 2003) are 9, 10, 12, 15, 18, 20,25,30,35, and 40mm. Thicknesses ranging from 12mm and below are classified as thin while those between 13mm and 22mm are medium. Any thickness more than 22mm is said to be thick. The European Standard validated by Estonia Republic Standard (EVS-EN 312:2003) gives range of thicknesses for standard particleboard as ranging from 3mm to 40mm.

The Australian Standard gives limit values for specific mechanical and physical properties of standard particle board as shown below Table 2.3:

Table 2.3 Typical Property Values For Standard Particleboard.

Property	**Unit**	**Thickness in mm**		
		≤12	13-22	>23
Density	Kg/m^3	660-700	600-680	600- 660
Modulus of Rupture (MOR)	Mpa	18	15	14
Modulus of Elasticity	Mpa	2800	2600	2400

(MOE)				
Thickness swelling (24hr)	%	15	12	8

(Adapted from facts about particleboard and MDF-AWPA 2008)

Most manufacturers of particle board use raw materials from industrial wood residues commonly sawdust, shavings, offcuts and slabs and round wood such as logging residues, thinning and some wood that are not commercial species (Hermawan et al., 2009). Wood species like Norway spruce and scots pine (Boonstra et al., 2006), have also been worked on and found to be suitable for particle board production. One of the key ways to combating deforestation is to reduce the consumption of wood. Noting that wood find its common application in home fixtures, furniture and fuel, finding substitutes will be most advantageous. Using agricultural wastes for particleboard production may be one of the options. Agricultural waste is an inexpensive and abundantly available source of liqnocellulosic fibres (Boquillo et al, 2004). The most commonly occurring agro-straw materials in Nigeria are rice, maize, sorghum and sugarcane. Animal wastes such as bones, snail shells, feathers and periwinkle shells also are very much available

in Nigeria. As the demand for wood products increase, researchers have to look at possible alternatives to natural wood, and agricultural residues can readily be utilized as substitute raw materials for the production of particleboard.

Particle board as a product of agricultural waste may be one of the best and effective ways of conserving the environment. However the cost of this substitute is high due to use of resins. As for analysis, resins consume 60% of the cost of particle board (Biswas et al, 2011). Thus, eliminating or reducing the use of resin will bring down the cost of particle board and can be made available at a cheaper price. With growing rate of unemployment, manufacturing of particle board may hold a large potential for employment at village level, when small capacity and low cost plants are developed (Kozlowski and Helwig, 1998).

Several researches on agricultural residues such as rice husk, straw (corn, sugarcane) and cane bagasse are generated every year by agricultural business activities. A portion of these residues are simply burnt, although the agricultural sector has been using some of the rice husks waste available while the sugar and alcohol sector has been using some of the bagasse waste available. Environmental legislation is becoming increasingly stricter, with the burning of crop residues posing a major problem for agricultural usage thus the need to seek alternative use for generated waste.The standard for interior fitment of board thickness is shown in table 2. 4

Table 2.4: The standard for interior fitment (including furniture) of board thickness range (3-4) mm.

Property	**Thickness**	**Test method and required values**
Bending strength – Modulus of Rupture (MOR)	3.2mm	ANSI,208.1 (14MPa minimum) and EN312-1 (11.5MPa minimum)
Modulus of Elasticity (MOE)	3.2mm	ANSI, 208.1 (1400MPa minimum) and EN312-2 (1600MPa minimum)
Ultimate Tensile strength	4mm	EN-312-1 (0.24MPa minimum)
Percentage elongation	4mm	ASTM (0.3% minimum)
Water absorption	-	ASTM D638 (20-75)% and ANSI, 208.1 (0.35%minimum)
Thickness swelling	-	ASTM D638 (5-15)% and ANSI, 208.1 (8%minimum)
Density	4mm	ASTM D792 (0.5-0.9)g/cm^3

Source: ANSI,208.1– 1999, ASTM D792,2011, ASTM D638,2003, EVS-EN312:2003

2.7 SIEVE ANALYSIS

Aliyu and Abdullahi (2012) studied the effect of various sieve sizes and properties which gives 1.0. From the study,it showed that the compressive strength decreased as the percentage passing is increasing. This means that the smaller the particle size is, the composite will consume more particulate and then build more energy and at same time increased in adhesive consumption. However, when the particle is too small it will develop a static charge during sieving.

CHAPTER THREE

MATERIALS AND METHODS

3.1 MATERIALS AND EQUIPMENT

The materials and equipment used in the various tests carried out are presented in this chapter.

The materials used for the various tests include Periwinkle shell Particulate, Bagasse particulate, recycled low density polyethylene, and water.

The equipment used for the various tests include oven, mill machine (grinder), sieve,minipal 4 XRF epsilon panaltical machine, crucible, basin container, scissors, razor blades, Reliable 2-Roll mill machine, metallic moulds, and electrically heated hydraulic press.

3.2 SAMPLE PREPARATION AND ANALYSIS

3.2.1 Low density polythene

Empty‘pure’ water sachets were gathered from Mando community in Igabi Local Government Area of Kaduna State. The choice of low density polythene is because of its binding characteristics (Yinusa, and Kolo, 2011). The standard of processing involved washing, drying and cutting into small pieces using shredder, scissors or blades for ease of compounding.