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Development of Pulverized Polyethene Bags and Powdered Palm Kernel Shell Composite

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Abstract

The mechanical properties of recycled polyethylene (RLDPE) re-inforced with palm kernel shell (PKS) particulate composite were evaluated to assess the possibility of using it as a new material for engineering applications. The composites were produced by mixing and compressive moulding technique using an available metal mould of size 250mm x 250mm x 50mm. Palm kernel shell of particle size 2000µm was mixed with RLDPE from 20 - 50 vol%. The hardness of the composite increases with increase in palm kernel shell content and the tensile strength of the composite increased to optimum of 20 vol%. The composites produced with 50% RLDPE and 50%PKS have the best properties of the entire grade. Hence this grade can be used for interior applications such as car seat, dashboard, and car interior for decorative purposes or other interior parts of automobile where high strength is not considered a critical requirement.

1.0. Introduction

Over the last decade, polymers reinforced with natural fibre composites, have attracted attention from the academic world and various industries. The rapid growth in the consumption of plastic products, persistence of plastics in the environment, the shortage of landfill space, the depletion of petroleum resources and entrapment by the ingestion of packaging plastic by marine and land animals have spurred efforts to look for better alternatives [1]. Polymers have relatively high strength and stiffness and no skin irritations effects [2].

Composites are combinations of two or more materials with different composition or form. The constituents retain their identities in a composite and do not dissolve or merge but act together. A composite may have a ceramic, metallic or polymeric (thermoset or thermoplastic) matrix. The fibres can also be ceramic, metallic or polymeric, however, a more common classification relates to whether they are synthetic (e.g. glass fibre, carbon fibre, Kevlar fibre) or natural (wood fibre, hemp fibre, flax fibre, oil palm fibre, jute fibre, etc). Therefore, the number and variety of composites available are very large. Fibre-reinforced composite materials commonly consist of fibres of high strength and Young's modulus embedded in, or bonded to, a matrix with a distinct interface between them. In general, the fibres are the principal load carrying members, while the surrounding matrix holds them in the desired location and orientation, acting as a load transfer medium between them [3].

Natural fibres are gaining importance and increasingly in demand across a wide range of polymer-composite materials and in the manufacture of bio-composites for various applications due to their desirable properties [4]. They originate from plants, crops, animals, agro waste or other natural sources that are natural, renewable, and biodegradable after their end use.

Mechanical properties of plant fibers are much lower when compared to those of the most widely used competing reinforcing glass fibers. However, because of their low density, the specific properties (property-to-density ratio), strength, and stiffness of plant fibers are comparable to the values of glass fibers [5-6]. Plant fibers are light compared to glass, carbon and aramid fibers. The biodegradability of plant fibers can contribute to a healthy ecosystem while their low cost and high performance fulfill the economic interest of industry.

Oil palm fibres have been extensively studied to produce various composites, such as thermoplastic composites, particleboard, medium density fireboard polymer impregnated oil palm trunk and other thermoset composites [5]. For thermoplastics composites, empty fruit bunch and oil palm frond has been the focus of many researchers. This is due mainly to cost, availability and properties. Oil Palm Fibers has been discovered to introduce better wear characteristics to polyester compared to glass fiber while it showed lower mechanical property than Chopped strand mat Glass fiber Reinforced Polyester [6-8].

The disposable component of harvested agricultural product (palm kernel) and pelletized pure-water nylon are becoming increasingly problematic in Nigeria, littering the rural and urban areas of the country, and constituting a serious threat to environmental health of the nation. The purpose of the research is to explore the potential of using palm kernel shell (powder) as reinforcement in polymer matrix composite for the development of new engineering material for general purpose requirement.

2.0. Methodology

The palm kernel shell used in this work was bought from the market. The PKS was sundried and milled into small particles.

The low-density polyethylene Sachet used were picked literally from the streets of Benin City and refuse dumps in University of Benin, Benin City, Edo State and torn open cleaned and sundried.

The dried LDPE sachet were then fed into specially designed LDPE milling machine which came out in flakes and was further ground with convectional grinder. While the PKS was sundried and grinded by our commercial market milling machine.

The materials were sieved to obtain particles of 2000μm and 2300μm for PKS and polyethylene, respectively.

After sun drying the materials for 24 hours, the PKS and low-density polyethylene (LDPE) were thoroughly mixed. The composite production was carried out on a hydraulic press. The chosen parameter value (low-high) for temperature, time and pressure are in line with the production parameter of a conventional board with different compositions. As was shown by [9], Moulding Load is 120 – 250kN; Moulding temperature is 150 – 200^{o}C; Holding time is 5 – 10mins.

The mixtures were then placed in a square mould with a size of 259 by 250mm as shown in fig 3 below. Heat was introduced to the mould through heaters attached to a thermo-couple as shown in fig 4. The material was then allowed to heat up to a temperature of 200^{o}C. After attaining the desired temperature, it was then pressed to a pressure of 2.4N/mm^{2} (150kN) for 5 minutes.

At the end of the press cycle, the mould was removed from the hydraulic press and the product was ejected from the mould and then kept for it to cool.
Variables for the composites production in the ratio of Polyethylene (%) to Palm Kernel Shell (%) are: 50:50, 60:40, 70:30 and 80:20 referred to samples 1, 2, 3 and 4 respectively.
The produced composite materials were cut to different sizes depending on the test carried out in accordance with the recommended standard for each test [10].
The tensile properties of the composite board sample were conducted on Avery-Denisen Universal testing machine as specified by American Society testing and Material (ASTMD638).
The impact test of the composites produced in accordance with ASTM using a fully instrumented Avery-Denison Impact Testing Machine. Charpy impact tests were conducted on notched samples. Before the test sample was mounted, 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 material was released from the freely swinging pendulum.
The rate of water absorption of the samples was determined by initially weighing dried samples and placed in a beaker with water and reweighed after 24 hrs. The water absorption rate was then determined.
The densities of the produced composite materials were first determined based on different compositions of produced composites. The density of the individual sample produced was determined by weighing the product in a weighing machine (Avery 3kg Lever Balance) while the volume was obtained by measuring the height and diameter of the produced composites. The density (D) was determined using the formula D = M/V, Where D = Density, M = Mass, V = Volume.

Fig. 1: Mould

Fig. 1 shows the metal mould dismantled after the composite board production. The mould was lubricated for easy ejection.

Fig. 2: Composite materials of the different compositions after ejection from mould

Fig. 3: Prepared composite materials

Fig. 3: Shows the prepared samples for the tensile strength and impact energy tests

3.0. Results and Discussion

Visually, macro structural studies of the composites revealed a uniform distribution of PKS particles with the LDPE particles. The distribution is influenced by the compounding of the particles and the binder and good interfacial bonding.

Table 1: Result of Tests

Sample	Density (g/cm^3)	Water absorption (%)	MOE (MPa)	UTS (MPa)	Impact Energy (Joules)
1	0.958	8.89	2145	4.6296	0.8
2	0.870	8.89	1520	4.2520	0.8
3	0.774	10.00	1818	4.1096	0.2
4	0.840	12.50	1619	6.6667	0.2

Samples: 1- 50vol% PKS; 2- 40vol% PKS; 3- 30vol% PKS; 4- 20vol% PKS.
From Table 1, the density decreases as the PKS vol% decreases, the water absorption increases as the vol% PKS decreases, modulus of elasticity was maximum at 50vol% PKS, the ultimate tensile strength was optimum at 20vol% PKS and impact energy decreases as PKS vol% decreases. Thus, the composition with 50vol% Polyethylene and 50vol% Palm Kernel Shell was found to have the best mechanical properties.

4.0. Conclusion

From the result of the investigations and discussion, the following conclusion has been made. This work successfully shows that the fabrication of RLDPE and the palm kernel shell particles composite by mixing and compressive moulding is feasible. The uniform distribution of palm kernel shell particle in the microstructure of the composite is the major factor responsible for the increase in strength. Palm kernel shell improves the hardness property of the recycled polyethylene matrix composite. The composite produced with 50% polyethylene and 50%PKS has the best properties of the entire grade. Hence this grade can be used for interior applications such as car seat, dashboard and car interior for decorative purposes or other interior parts of automobile where high strength is not considered a critical requirement.

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