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Characterization of Bush Mango Fiber and Shell Particles Reinforced Polyvinyl Chloride for Indoor Applications

Kuri A. A., Abubakar A.B., Maina M.N. and Usman I.
Department of Mechanical Engineering, Ramat Polytechnic Maiduguri, Nigeria

Abstract: *There has been needs for high strength but low density materials with low cost, it was against this backdrop Bush mango fiber and shell particles reinforced Polyvinyl Chloride was developed and characterized. Highest tensile strength was obtained at 15wt. % fiber/shell loading while maximum impact strength was recorded at 10wt. % of the reinforcement. Micrograph of scanning electron microscopy of 10wt. % reinforcement shows that there was clear miscibility between the reinforcement and the PVC matrix. It was also observed that the fiber and the shell particles behaved more as filler than reinforcement. The composite produced can be used as partition wall and other indoor applications.*

Key words: *Bush mango, particles, Polyvinyl Chloride, indoor*

1. Introduction

There has been an increasing demand for materials that are stiffer and stronger but lighter in weight. In order to achieve this, fiber reinforced polymer composites are produced and characterized. Composites are now considered as one of the most important classifications of engineering materials. This is owing to the fact that they offer several more outstanding properties in comparison with conventional materials. Composites can be defined as combination of two or more chemically distinct and insoluble phases with properties and structural performance superior to those of either of the constituents acting independently (Kalpkjian and Schmid, 2007). It is the superior properties of constituents that determine the characteristics of the composite material hence their weaknesses has little or no effect on the overall properties of the composite. The two constituents that made up the composite are regarded as the reinforcement and matrix, each of which performs vital functions. The earliest composites used was made by mixing straw and clay of certain proportion for making mud huts and bricks for structural purposes, date back to 4000 BC.

In that composite, the clay served as the matrix while the straws were used as the reinforcing fibers (Kalpkjian and Schmid, 2007). Generally plastics possess mechanical properties such as strength, stiffness and creep resistance which are inferior to those of metals and alloys. These properties can be improved by embedding reinforcements of several types such as glass or graphite fibers to produce reinforced plastics or composite. These reinforcements enhance the desirable properties of plastics. Reinforced plastics today found application in many industries like aircraft, space vehicles, pipes, electronics, automobiles, boat, ladders, sporting goods and construction (Kalpkjian and Schmid, 2007).

Among the polymer types, Polyvinyl Chloride (PVC) is one of the most widely used engineering materials (Wirawan *et al*., 2009). Being a hard thermoplastic, PVC finds application in areas such as building construction, production of pipes, plumbing and many other applications. PVC is cheaper and its price is less influenced by the price of petroleum and natural gas and this is due to high quantity of chlorine which constitutes about 56% by weight of the PVC. In addition to the lower cost of PVC resin, there are several reasons why PVC has the wide range of applications, some of these include; ease of fabrication, durability, resistance to wide range of corrosive fluids, higher strength and rigidity compared to other types of thermoplastics (Nass, 1985; Willoughby, 2002). PVC is also highly responsive to functional additives which facilitates the generation of rigid and flexible products, which are desirable in engineering applications. Despite these advantages, there are still several safety and environmental problems associated with PVC. Mixing PVC with natural fiber forming natural fiber- PVC composites can minimize some of these problems (Ayora, *et al.,* 1997). In the last decade, natural fiber have attracted a lot of attentions, this is due to their advantages over other conventional reinforcement materials. Glass-fibers for instance, when subjected to combustion process or landfill at the end of their life cycle, the CO_2 released by the fibers is neutral in comparison with the assimilated CO_2 during their growth. Abrasiveness of natural fibers is much less than that of glass-fibers, which is essential in technical, material recycling and composite materials production processes. Similarly the density of natural fibers is much lower compared to that of glass-fibers. This implies that the composites of natural fibers are of light weight (Bledski and Gassan, 1999).

A lot of work have been done in the field of natural fiber reinforced polymer composites by many researchers because of the potential importance of these composites in the near future. Subba, *et al*., (2017) studied the mechanical properties of banana fiber reinforced epoxy and reported that as the volume of fiber increased the density of the composite decreased and that the purpose of the reinforcement cannot be achieved when the percentage volume of the fiber was lower than 10% according to their findings but when the volume was increased to above 10% the mean tensile strength also increased. When the volume of the fiber was increased to 35% by volume, the tensile strength increased by 38.6%. They also reported that alkali treatment increased the flexural strength but lower the impact strength. Furthermore, Aditya, *et al.,* (2017) prepared and characterized fiber reinforced composite specimens of pineapple leaf fiber/epoxy, sisal fiber/epoxy, date palm/epoxy, sisal and pineapple leaf fiber/epoxy and glass fiber/epoxy. It was found that the glass fiber reinforced composite has the highest tensile strength, flexural strength and flexural modulus which is an indicator that glass fiber reinforced composite specimen has superior mechanical properties as compared to the natural fiber reinforced composite specimens. However, hybrid composite of sisal and pineapple has the highest elastic modulus while date palm reinforced composite specimen showed highest impact strength. Bak and kalaichelvan, (2016). Kabir, *et al.,* (2014) in their study investigated the physical and mechanical properties of bamboo fiber and PVC foam sheet composite of varying weight percentage of bamboo fiber and reported that the bulk density increases with the increase in percentage of fiber. Mechanical properties such as tensile strength flexural stress, flexural strain and tangent modulus also increased with the increase in fiber proportion. Increase in Young modulus was observed up to 10% of fiber loading beyond this, the young modulus began to decrease. Maximum young modulus was recorded at 8% fiber content in the composite. It was also confirmed from the result of their thermal analysis that the composite has a better thermal stability. Dan Asabe, *et al.,* (2016) conducted mechanical, spectroscopic and micro-structural characterization of banana particulate reinforced PVC composite and reported that the density decreased with the increased in fiber content while elastic modulus deceased. Optimum mechanical properties were observed at 8%, 62% and 30% formulation of banana stem particulate (reinforcement), PVC (matrix) and *kankara* clay (filler) respectively. They also reported that the water absorption increases as the percentage of fiber increases in the composite as reported by many researchers. FTIR results revealed that the banana particulate has characteristics of plant fibers spectral profile though with varying composition of cellulose, lignin and other minor constituents such as waxes and water soluble components. Scanning electronic microscopy analysis result showed fairly uniform distribution of the constituent phases. Nwigbo, *et al.,* (2016) conducted a research on effect of fiber content on the Physio-Mechanical Properties of Bush Mango *(Irvingia Gabonensis)* shell fiber reinforced Polyester composite. The results of the study revealed that the moisture uptake of the composites increased with increase in fiber loading but the hardness value decreased. They also observed that the sample containing 10%wt *Irvingia* fiber gave the optimum hardness value and lowest moisture uptake. Composite containing 18%wt *Irvingia* fiber gave the optimum impact strength while with 20%wt fiber has the maximum specific gravity.

2. Materials and method

2.1 Materials

- Bush mango fiber and shell
- Polyvinyl chloride(PVC)
- Sodium hydroxide (NaOH) solution
- Distilled water

2.2 Methods

2.2.1 Materials Preparation

The bush mango fiber and shell used as reinforcement was ground into powder and sieved to 150 μm. It was immersed in 5 % NaOH for 24 hours after which the solution was washed with distilled water until the solution becomes neutral and finally the fiber and shell were dried.

2.2.2 Composite Production

The Bush mango fiber/shell and the PVC were blended using brabender mixer and then compounded by compression molding at a temperature of 160 °C. The % weight fraction of the reinforcement was varied from 0-25 % (0, 5, 10, 15, 20, and 25). Samples obtained were then cut following ASTM standard in preparation for characterization.

2.3 Mechanical property test

The tensile and impact tests of the samples were done in accordance with ASTM D638 and ASTM D3763 standard respectively. The samples were machined to dumbbell shape and then placed in Instron universal tensile testing machine for the tensile test while charpy method was used for the impact test.

2.4 Morphology

SEM was used to study the adhesion and interactions between reinforcement and the PVC matrix JEOL JSM-5600LV Scanning Electron Microscope was used. In order to facilitate fracture the composite was dipped into liquid nitrogen. The samples were removed and broke into two portions. The specimens were placed on a stub, coated with platinum and inserted into the scanning barrel.

3. Results and discussion

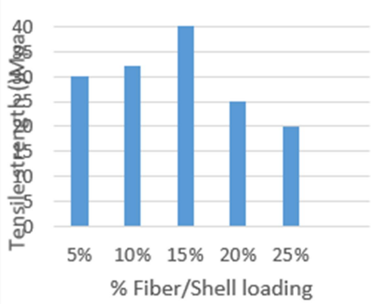
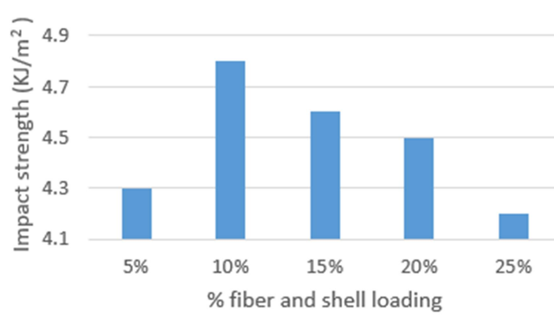


Figure 1 [Effect of fiber loading on tensile strength]

Figure 2 Effect of fiber/shell loading on impact strength



Mechanical properties

3.1.1 Tensile strength and elastic modulus

Figure 1 shows the ultimate tensile strength (UTS) of the composite with increasing weight of reinforcement. The tensile strength increased and attained maximum at 15% reinforcement and then drop thereafter. This is due to poor adhesion between the constituents of the composition as the fraction of PVC reduces with increase in weight percentage of bush mango fiber and shell.

Figure 2 shows that composite with 10 wt. % reinforcement has highest impact strength this trend continues throughout i.e. the reduction in impact strength continues up to 25 wt% fiber/shell which has the minimum impact strength.

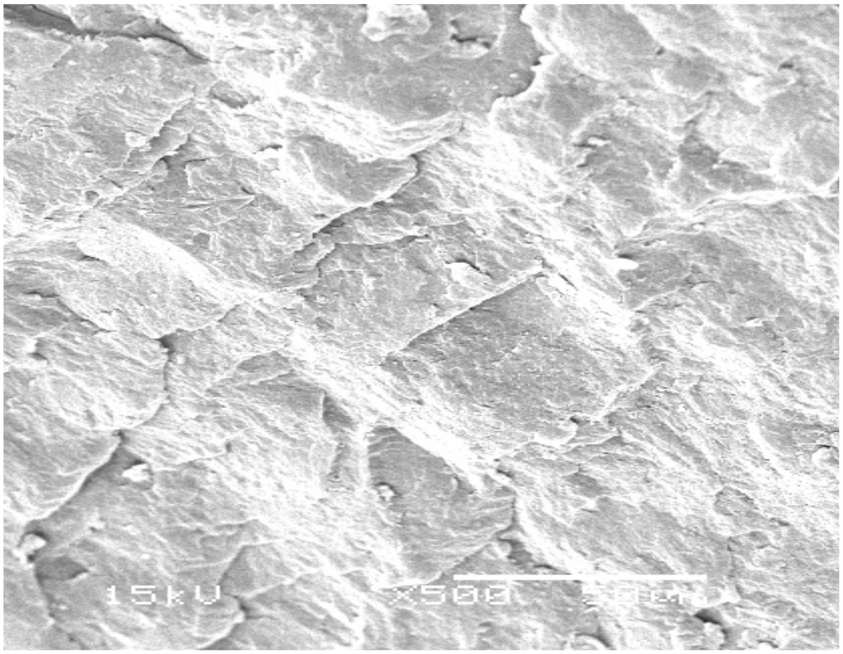


Figure 3 Micrograph of the composite at 500 magnification

Scanning electron micrographs is shown in Figure 3 with magnification of 500. At 15 wt% treated fiber/shell reinforcement, there was clear miscibility of constituents of the composite, however there was also some discontinuity in the composite which may be attributable to the particle size of fiber/shell reinforcement. This indicates that particles behaves more as fillers than reinforcement.

Conclusion

Composite of bush mango fiber and PVC has been produced and characterized. Highest tensile strength was obtained at 15wt. % fiber/shell loading while maximum impact strength was recorded at 10wt. % of the reinforcement. Micrograph of scanning electron microscope of 10wt. % reinforcement shows that there was clear miscibility between the reinforcement and the PVC matrix. It was also observed that the fiber and the shell particles behaved more as filler than reinforcement.

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