Production and Properties of Sweet Potato Flour/High Density Polyethylene Composites

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Abstract—High density polyethylene (HDPE) was filled using potato flour at different compounding ratios. The composites obtained were analyzed to establish the effect of the filler on the physico-mechanical properties of the high density polyethylene polymer. Density was observed to increase from about 0.91g/cm³ to about 1.20 g/cm³ with increase in filler loading. Water absorption of the composites was found to increase with increase in filler loading from about 0.005 to about 3.2 g when the composites were submerged in water for 144hours. Hardness also increased from about SD68 to SD78. Tensile strength decreased from about 31.8 to about 23.1 MPa. Similarly, the Impact strength decreased from about SD68 to SD68. Tensile strength decreased from 300 to 195 J/m as the filler content increased from 0 to about 90%.

Keywords Density, water absorption, hardness, tensile strength, impact resistance sweet potato

I. INTRODUCTION

Composites are simply those materials formed by aligning extremely strong and stiff continuous fibers in polymer resin matrix or binder. They are composed of a mixture or combination of two or more macro constituents that differ in formula and/or material composition and that are insoluble in one another [1] (Bhatnagar, M.S., 2004).

The materials in this class have exceptional mechanical properties and are hence often termed as reinforced material as in the case of polymers, reinforced polymers [2] (Herman, F. et al., 1985).

Among other means, the reinforcement of polymer can be achieved by the employment of fillers; relatively inert substances added to a polymer composition to improve its properties and/or reduce cost [3] (Rosato, 1982).

The use of fillers dates from the time of ancient Egyptians that used ground lime to thicken paints, mastics and plaster. With the development of polymers in the early 1900’s fillers were needed to meet key functional requirements [2] (Herman, et al., 1985). As industrial activities increase, the use of fillers also increases and came to the climax in 1970’s [4] (Hampel, 1973), when the shortage of petroleum product combined with their prices consequently resulted in the shortage of resins and their price escalation.

Today, fillers dominate the field of composites or reinforced plastics. These fillers can be material, metallic powders, organic by-products or synthetic inorganic compounds [5] (Harry, 1978).

Organic fillers like other fillers have been useful as additives for plastics throughout the history of plastic industry. When the earliest phenolic resins were first made they were combined with wood flour as one of the additives [5] (Harry, 1978). Some organic fillers have also been successfully employed in polyolefin polymer to improve processability, reduce cost and improve the properties of the final compound.

Sweet Potato is readily available as Agricultural product. It is believed that production of biodegradable composites will not only address environmental pollution, but will also introduce a novel material.

Sweet potato (Ipomoea batatas) is a dicotyledonous plant that belongs to the family Convolulaceae. Its large, starchy, sweet-tasting, tuberous roots are a root vegetable. In 2011 about 106.5 million tons of sweet potato was estimated to have been cultivated according to [6] (Food and Agriculture Organization of the United Nations[6]). In the same year, about 2.8 million tons were produced in Nigeria. It is observed that apart from usage as food, sweet potato is being wasted. So this work intends to study the composites of sweet potato flour and HDPE so that it will help in reducing the waste and attempt to produce biodegradable composites.

The research is carried out in view of investigating the possibility of producing polymer composite using sweet potato flour and HDPE.

II. METHODOLOGY

2.1. Preparation of Sweet Potato Powder

Sweet potato was washed, peeled and dried under the sun. It was then grinded and sieved to 200µ.

2.2 Compounding of the Composites

Various quantities of the potato flour and high density polyethylene were weighed increasing the amount of sweet potato flour by 10%.

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Two roll machine was started and left to warm for about one hour and the temperature was set at 150°C. HDPE was compounded on the two roll-mill machine with the Sweet potato flour. The mixture was then assembled in hydraulic hot press and pressed at 150°C to form the Sweet Potato Flour/High Density Polyethylene (SPF/HDPE) composites.

2.2 Determination of Density

The sample was weighed using weighing balance, then the weighed sample was immersed into a eureka tube filled with water to obtain the volume of the sample.

2.3 Determination of Water Absorption

The sample was weighed using weighing balance and immersed in a clean container filled with water. The sample was removed from the container and re-weighed after every 24hrs for 6days to determine the weight of water absorbed.

2.4 Determination of Hardness

The hardness of the composites was measured in accordance with ASTM 2240 method on a Durometer. The samples were cut from the cured composites using square shaped cutter; the thickness of the sample was measured using micrometer screw gauge. The sample was then placed on the Durometer and the indenter pin was forced to penetrate the sample, the hardness of the sample was shown on the dial. The process was repeated 3times for each of the samples.

2.5 Determination of Tensile Strength

The dimensions of the samples were taken (thickness and width) using micrometer screw gauge. An autographic recording drum was cover with the special graph sheet securing it with the long spring clip.

Specimen was inserted into the Tensometer using the split chucks and pins, the recording drum was rotated and the picker was set on the zero axis of the graph sheet. The load extension diagram was traced by following the mercury column with the sliding arm and depressing it to mark the graph sheet at regular intervals. The load handle was turned continuously until there was fractured.

2.6 Determination of Impact Strength

The test was carried out according to ASTM256 method. The sample was held between the jaws of the clamp on the machine, an arm held at specific height was released to hit the sample, its impact strength was determined from the energy absorbed by the sample. The result was in energy lost per unit of thickness (J/m).

III. RESULTS AND DISCUSSION

3.1 Density

From figure.1, it is observed that the control sample gave the lowest density of about 0.91g/cm³. As the filler loading increases the density of the SPF/HDPE composites also increases. This may be due to the fact that as the filler is added, it makes the composites heavier, thus increasing the density. This is not in conformity with previous results of density measurement of similar composites [7][8]. It is possible that the sweet potato flour has weighing effect on the composites thus causing increase in the density of the composites with increase in sweet potato flour content.

![Figure 1: Density of composites against filler loading](image1)

3.2 Water Absorption

The water uptake of the composites increased with increase in filler content. This should be expected, because sweet potato flour is hydrophilic and therefore as its content increased, the amount of water absorbed by the composites increased. Figure 2 shows that between 10 and 60% sweet potato flour content, the amount of water remain about the same, but steadily increased above the 60% content. This indicates that at that range of sweet potato flour, the composites can fully integrate the flour and hence maintain about the same weight of water absorbed. Similar results have been reported while studying water uptake and flexural properties of natural filler/HDPE composites [9].

![Figure 2: Water Absorption of composites](image2)
Figure 2. Water absorption of composites against filler loading

3.3 Hardness

Figure 3 shows that as the filler loading increased, the hardness values increased. This may be as a result of proper dispersion of the potato powder in the matrix which led to uniform distribution of the filler in the body thus allowing the hardness to increase with increase in filler content.

3.4

The tensile strength appeared to be lowered with increase in filler loading as can be seen in figure 4. It is generally expected that with increase in filler loading, the tensile strength of polymer composites will be impaired. This has been attributed to the interference in the cross linking of the matrix as a result of inclusion of the filler. Similar observations have been reported [10].

3.5 Impact strength

Figure 5 reveals that the impact strength of the potato/HDPE composites decreases with increase in the filler content. This can be as result of the reduction in the degree of intra molecular cohesion as a result of the presence of the filler in the polymer matrix. Similar results have been reported [11]. However, it can be seen that despite the decrease in the impact resistance values, the composites of potato/HDPE show fairly good values which can make them find useful applications.
IV. CONCLUSION

Composites of potato/High Density Polyethylene have been produced and some of their physical and mechanical properties tested. The results show that the composites can be successfully employed in normal household applications for the composites. Similarly, since the potato component of the composites is biodegradable, it means the composites will degrade with time when exposed to the right environment of heat and moisture and can thus be environmentally friendly.

REFERENCES