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DEVELOPMENT AND CHARACTERIZATION OF WOOD FLOUR – REINFORCED POLYETHYLENE MATRIX COMPOSITES

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ABSTRACT

The development of wood plastic composite (WPC) is presented in this paper. The WPC has been formulated from locally available waste materials by using various percentages of recycled polyethylene (PE) as matrix reinforced with various amounts of wood flour (WF). Two different wood flours, iroko and tap rubber, have been used, with particle sizes of 250μm and 600μm. For each particle size and WF type, four different weight percentages of reinforcement, 0%, 15%, 30% and 45%, were developed, with the corresponding percentages of PE matrix set at 100%, 85%, 70% and 55%. The physical and mechanical tests carried out include water absorption, density, hardness and tensile tests. Experimental results revealed that as the WF percentage increased, the density of the WPC increased initially, and then decreased from a peak value, regardless of the WF species. The tap rubber WF particle sizes of 250μm and 600μm absorbed more water than the iroko WF of the same composition. The mechanical tests showed that the hardness and tensile strengths of the WPC decreased with increase in the WF loading irrespective of the WF type. The results indicate that 30% WF and 70% PE gave the best formulation for the WPC.

Keywords: *Wood flour, recycled, polyethylene, formulation.*

1.0 INTRODUCTION

Wood plastic composites (WPCs) have received considerable attention in recent times. They are globally beginning to rank among the most preferred building materials due to their good mechanical properties and their stability under most conditions [1]. Increase in world population has led to increase in material consumption, resulting in an increase in waste generation on daily basis. Consequently, plastics and wood have been the sources of a major environmental concern. Waste plastics constitute a very serious problem because of the alarming amount of the waste generated daily [2]. Recent reports show that the global production of plastic waste has increased from 1.5 million tons in 1950 to 245 million tons in 2008. Out of this, 28.9 million tons were land-filled, 2.6 million were burnt with some energy recovery, and 2.2 million tons were recycled. Recycling is not adequately practised in developing and under-developed countries such as Nigeria, where percentage recycling of waste plastics is minimal [3,4]. This same problem applies to waste wood materials, although to a lower extent. With wood; the waste is generally burnt or otherwise disposed of in other ways [2]. Adhikery (2008) reported that a large amount of wood waste is generated at different stages during the processing of wood [5]. There are no accurate records of the amount of wood waste generated. Recycling of wood waste helps to overcome the problems of solid waste disposal, conserves natural resources, and saves energy and cost [6].

Wood plastic composites (WPC) are produced by dispersing wood flour in molten plastic to form the composite through different processing routes, such as extrusion, compression, and injection molding [7 - 10]. The essence of this study is to develop WPC using locally sourced waste materials and thereby to help solve the environmental problems associated with the littering of “pure water” polyethylene sachets in public places.

2.0 MATERIALS AND METHODS

2.1 Materials and Equipment

The materials used for this work include polyethylene (PE) resin obtained from a retail shop at Upper Iweka, Onitsha in Anambra State. This PE is a product of the Eleme Petrochemical Company, Ltd. Eleme, Port Harcourt, and has a melting point of 101^{0}C, a melting flow index that ranges from 0.2 – 3.0g/10 mins, and a density at room temperature that ranges from 0.941 – 0.965g/cm^3. Waste PE was also used together with sawdust collected from a local sawmill at Naze, Owerri, Imo State.

The equipment used include an OCP – 04 digital weighing scale, mixer, sieves, oven, grinder, hydraulic press, electronic heater, a desk-top tensometer, and a Rockwell hardness testing machine.

2.2 Experimental

The sawdust was ground and sieved to obtain 250μm, and 600μm particle sizes. It was then dried in an oven for 24 hours at 40^{0}C. The oven-dried sawdust and recycled polyethylene were carefully weighed out to obtain each formulation as presented in Table 1.

The raw materials were blended using a high speed mixer and were then poured into a 5cm, diameter steel die. The samples were subsequently hot pressed for approximately eleven (11) minutes at 200^{0}C and with a reassure of 70kg/cm^2. Specimens were then prepared for water absorption tests, density measurement, hardness tests and tensile tests.

Table 1: Composition of Experimental Formulations

Specimen	Wood flour (wt%)	Polyethylene (wt %)
Polyethylene (PE)	0	100
TRB – 250μm – 1	15	85
TRB – 250μm – 2	30	70
TRB – 250μm – 3	45	55
TRB – 600μm – 1	15	85
TRB – 600μm – 2	30	70
TRB – 600μm – 3	45	55
IRK – 250μm – 1	15	85
IRK – 250μm – 2	30	70
IRK – 250μm – 3	45	55
IRK – 600μm – 1	15	85
IRK – 600μm – 2	30	70
IRK – 600μm – 3	45	55

3.0 RESULTS AND DISCUSSION

The results displayed in Figure 1 show that with increase in wood flour content from 15% to 45%, the quantity of water absorbed also increased. The tap rubber wood flour of particle sizes 250μm and 600μm absorbed more water than the iroko wood flour of the same sizes.

Figure 2 shows that the composites with 30% tap rubber wood flour of particle sizes 250μm and 600μm have average densities of 1.00kg/cm^3 and 1.01kg/cm^3 respectively. Similarly, the average densities of the iroko wood flour of 250μm and 600μm are 1.09kg/cm^3 and 0.95kg/cm^3 respectively.

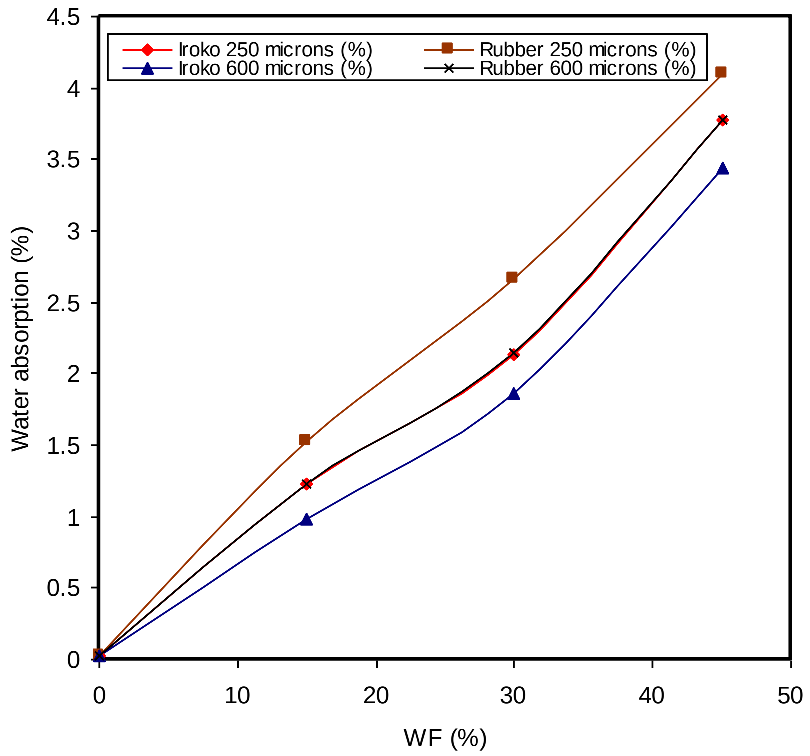

Fig 1. Water absorption % versus wood flour, after 24hrs imersion

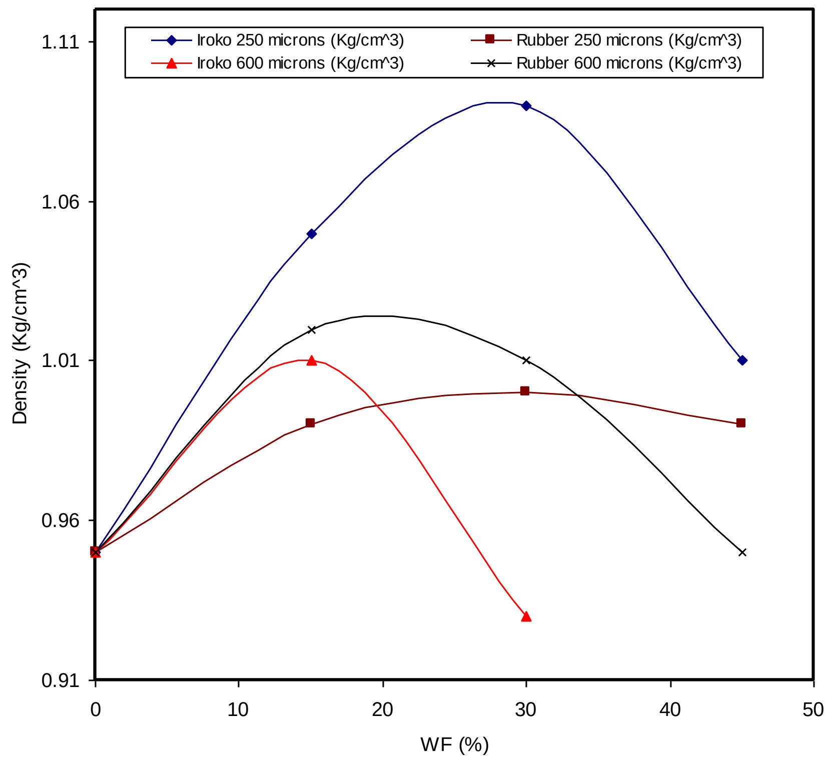

Fig. 2. Variation of density of WC with % wood floor in WPC

Generally, Figure 2 shows that with increase in wood flour content, the density of the composite initially increases but subsequently decreases after reaching a peak value. The decrement may be due to the effects of porosity in the composites. Initially the effect of the wood flour particles in increasing the density overrides that of porosity. With further increase in percentage of wood flour, the probable increase in porosity might have led to the observed decrease in the density of the composites.

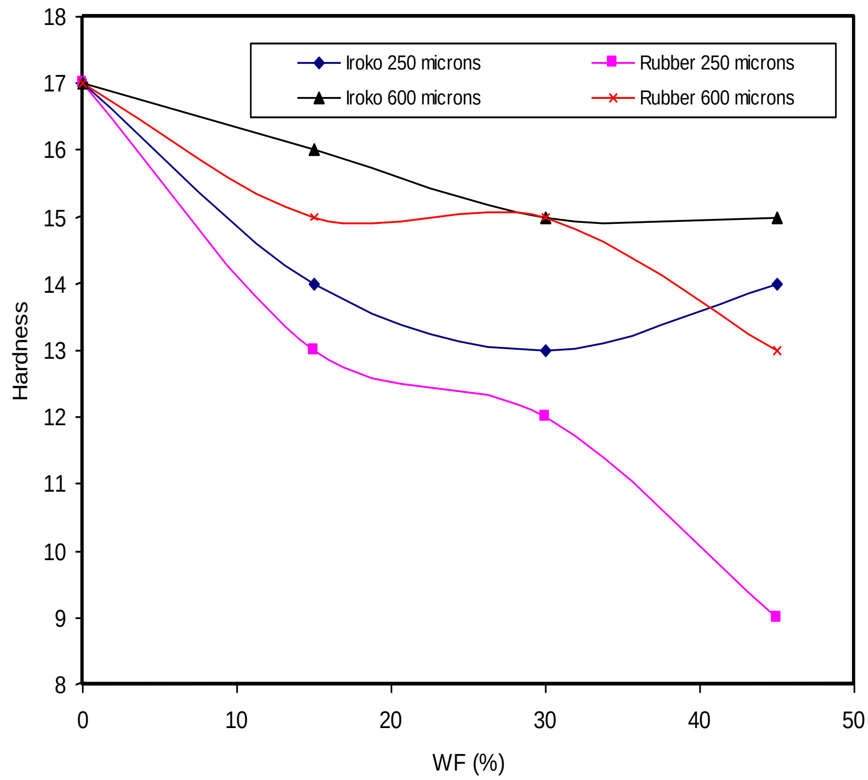

Fig. 3. Effect of % wood flour on Hardness of WPC

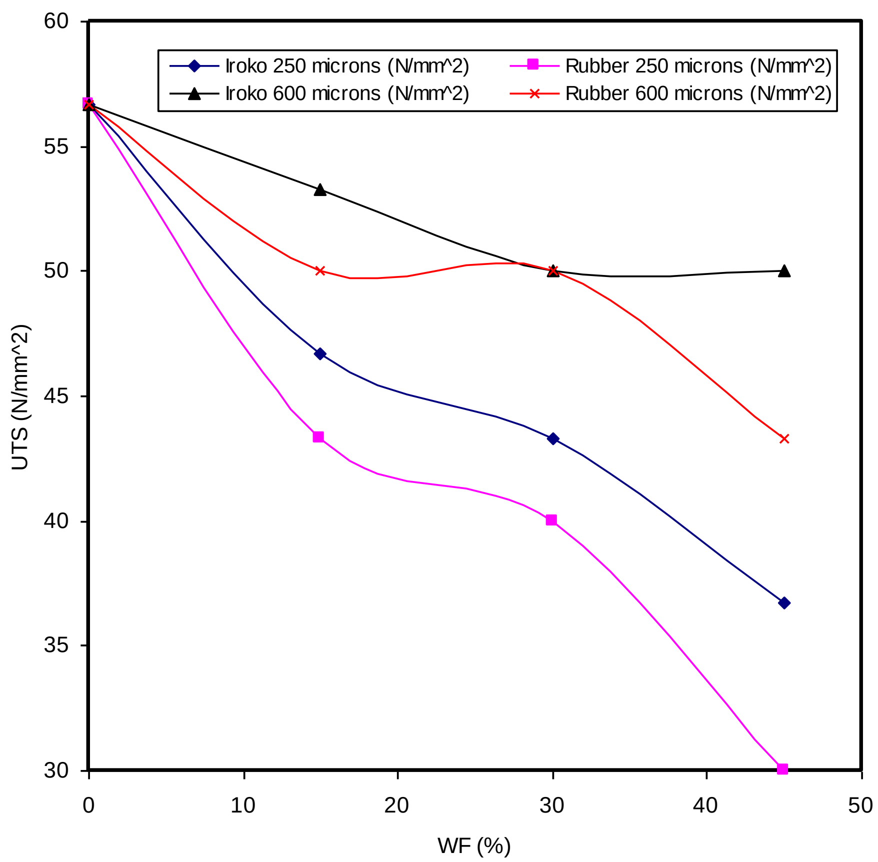

Fig. 4. Effect of % wood flour on tensile strength of WPC

Figure 3 shows that irrespective of the wood flour type, the hardness of the wood-plastic composite (WPC) decreased with increase in percentage of wood flour. The decrement was more pronounced in the composites with 250µm particle size reinforcements than in those with 600µm particle size reinforcements. Similar results are displayed for tensile strength values in Figure 4. Generally, the tensile strength values decreased with increase in the percentage of wood flour, but the composites reinforced with 600µm wood particle size had higher tensile strengths than those with 250µm wood particle size.

4.0 CONCLUSION

From the results obtained in this study, the following conclusions can be drawn.

- Increase in the percentage of wood flour reinforcement, regardless of the type of wood flour, results in an increase in water absorption.
- The density of the wood-plastic composite increases initially with increase in wood flour content, but later decreases from a peak value with further increase in the amount of wood flour.
- Hardness and tensile strength values of the composites decreased with increase in wood flour percentage.
- The experimental results show that the appropriate formulation for the development of the WPCs is 30% wood flour (WF) and 70% polyethylene (PE).
- From the point of view of water absorption, the 250µm wood particle size is preferable, since less water is absorbed with this particle size. On the other hand, from the point of view of the hardness and strength of the WPC, the larger 600µm particle size is preferable.

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