

Research Paper

Mechanical Properties of Wood Waste Reinforced Polymer Matrix Composites

This research work set out to investigate the mechanical properties of polymer matrix composites (PMC) produced from the use of wood waste. Low density polyethylene (matrix) was loaded with sawdust from African teak tree as filler, and Sodium hydroxide was the binder. The composite was compounded by compression moulding technique; composites with amounts of wood-waste ranging from 20, 30, 40, 50, and 60 wt. % were manufactured. Test result shows 40 wt. % was found to be the optimum reinforcement loading. Increasing particle load of African teak improves the strength and stiffness of the composites but decreases impact strength. Results also suggests that water absorption rate of composite was high in the first few hours with 60 wt.% reinforcement has the highest overall water absorption. Morphological analysis revealed that there were small discontinuities and a reasonably uniform distribution of wood particles in the polymer matrix.

Keywords: Wood waste, Polymer Matrix Composite, Mechanical Properties, African teak tree,

1. INTRODUCTION

Composite is a material formed with two or more components, combined as a macroscopic structural unit with one component as continuous matrix, and the other as fillers or reinforcements. Normally, the matrix is the material that holds the reinforcements together and has lower strength than the reinforcements. In the plastic based composites, the polymers, thermoplastics or thermoset, act as a matrix and particles of wood or other natural particles are fillers. The reinforcing particles are the main load-carrying component in the composites. It provides high strength and stiffness as well as resistance to bending and breaking under the applied stress. Interface bonding between the fillers and the matrix is the key to transfer the stress from the matrix into the fillers across the interface.

Investigations of polymer-based composite materials have opened new routes for polymer formulations and have allowed the manufacture of new products with optimal properties for special applications [1, 2]. The production of polymer matrix composites reinforced with wood flour is an established technology today [3-5]. And in order to achieve the required combination of properties, interfacial interactions are often modified in these composites. Interfacial adhesion can be achieved by the chemical modification of the wood, by surface coating or by the introduction of a coupling agent. The particle size of wood flour routinely used for the reinforcement of plastics is large and the particles easily debond during the loading of the composites that leads to the formation of large voids. A number of natural occurring fillers and fiber in composite have been studied in the past. These include wood fillers [3-6], wheat straw, almond husk, ash rice husk [7, 8], pineapple leaf, [9] coconut fruit fibers, Wood base filler derive from oil palm wood flour [10] etc. These fillers introduce

some advantages compared to traditional inorganic fillers, including their renewable nature, low density, nonabrasive properties, reasonable strength, and stiffness [11]. Using natural filler to reinforce the composite materials offers the following benefit in comparison with mineral filler [12, 13], strong and rigid, light weight, environmental friendly, economical, renewable and abundant resource. However they have the disadvantage of degradation by moisture, poor surface adhesion to hydrophobic polymers, non-uniform filler sizes, not suitable for high temperature application among others [14]. The objective of the research therefor, is to investigate the mechanical, water absorption and morphological properties of Low density polyethylene filled wood-waste composite

2. MATERIAL AND METHODS

2.1 Preparation of Wood Reinforcements

Wood samples were collected from African teak wood specie from a wood-mill in Bida, Nigeria. The samples were sun-dried for two days to remove excess moisture, they were there after soaked in hot water (100°C) for 1 hour, washed thoroughly and air-dried for three days at room temperature. They were then reduced to irregularly formed particles 1 to 2 mm in size in a plastic mill equipped with two rotating knives. The sawdust particle size, time of alkaline treatment, compression moulding parameters (time, pressure, and temperature), concentration of NaOH solution and HCl acid solution were held constant while only the wood sample contents were varied. [15]

2.1.1 Chemical Treatment of Wood Reinforcements

25g of the samples were introduced into 150ml of 20% NaOH solution and stirred vigorously with a mechanical stirrer for 30 minutes, the mixture was thereafter filtered and the residue dissolved in 100ml of prepared diluted Hydrochloric acid to remove excess NaOH. The mixtures were stirred, filtered and the residues collected. The treated samples were thoroughly washed five times with distilled water [16]. The treated fibre samples were air-dried at room temperature for three days, after which it was oven dried at 105°C until a constant weight was observed. The procedure was repeated until enough samples for the reinforcement of polymer was obtained.

2.1.1.1 Compounding of Wood Polymer Composites

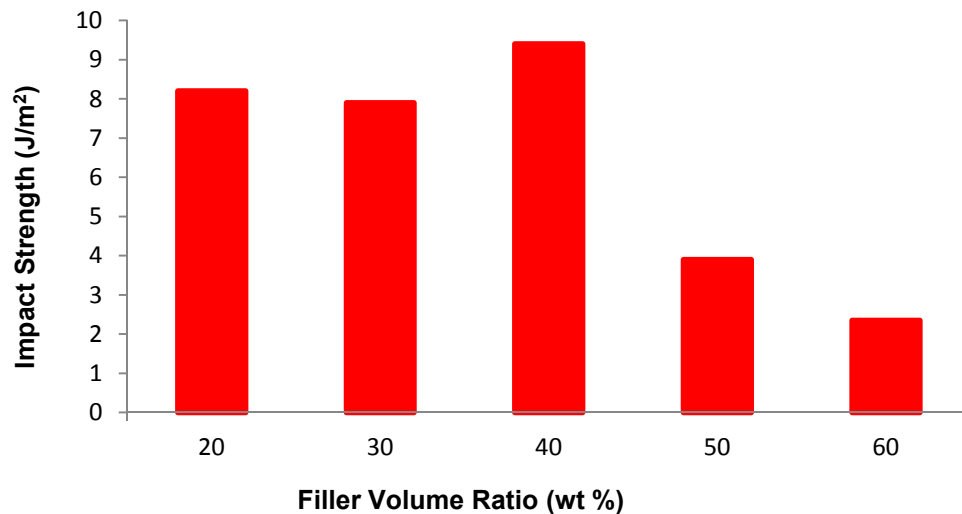
A 200 tons capacity compression moulding machine was used to compound the wood polymer composites. At first the female part of the mould was fixed on the carrier seat of the machine. The LDPE was poured into the oven system where it was melted and maintained at 180°C. At this stage the polymer was ready and the mixing of the wood particles with the molten polymer took place inside the oven system at temperature 180°C and pressure of 40kg/cm² for 10 minutes. The procedure was repeated for the various fraction loadings of the wood reinforcement. Impact test was carried out in accordance with ASTM D256, compression test in accordance with ASTM D695, water absorption test accordance with ASTM D570, while scanning electron microscope JEOL 6010LA. was used for surface morphology.

3. RESULTS AND DISCUSSION

3.1 Mechanical Properties

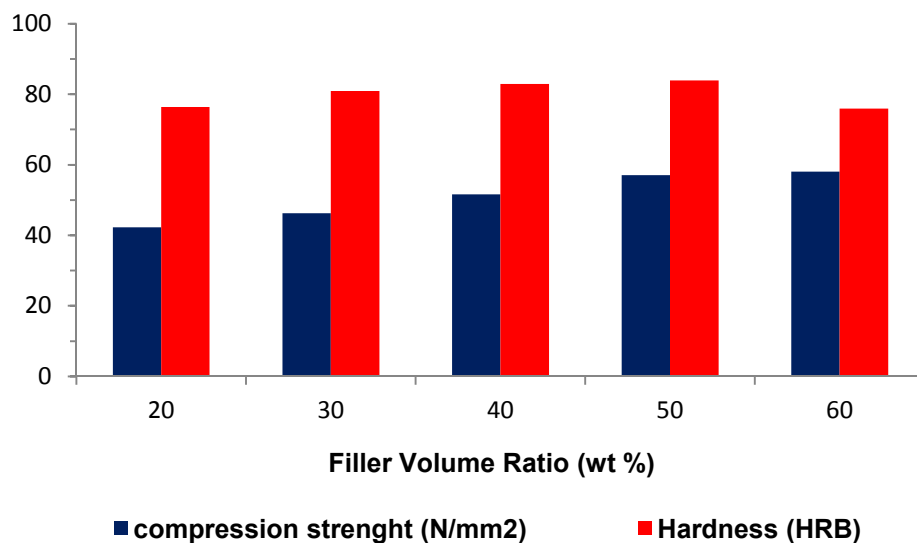
Fig. 1 indicates that as particle content increases, the composite becomes more and more stiff and less ductile. Obviously as the particle content is increased beyond 60% loading, the particle may not interact well with the polymer matrix and the interfacial adhesion meant to

88 give the composite the required stiffness and strength would be absent as the particles
89 aggregate.
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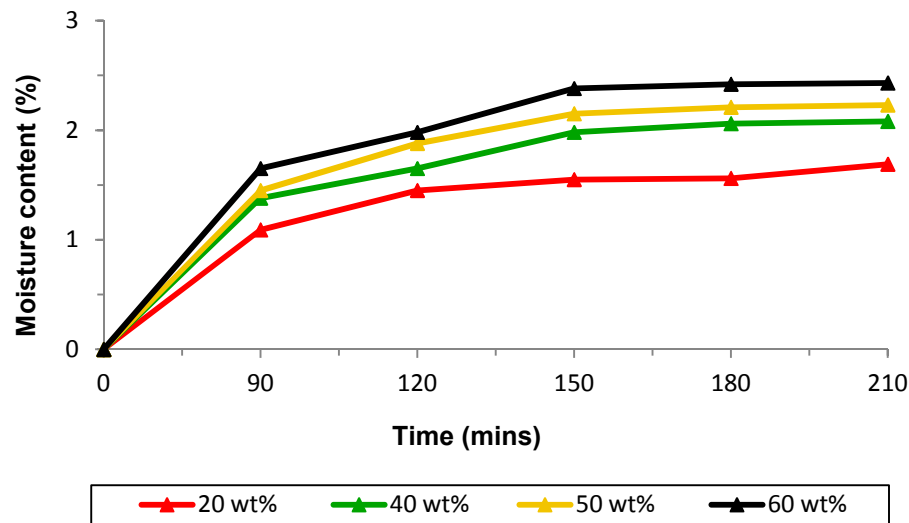
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93 **Fig 1: Effect of filler volume ratio on impact strength.**

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95 Fig. 2 shows how wood content affects the compressive strength of PMCs. Increasing fiber
96 load of African teak improves the strength and stiffness of the composites, hardness strength
97 also shows slight increases as filler volume ratio increase, and gradually decreases above
98 50 wt%. The water absorption test result are show in Fig 3, it is clear that the composites
99 absorb water very rapidly at the initial stage, and later a saturation level was attained without
100 any further increase in water absorption, it was also observed that as filler volume fraction
101 increases, water absorption capacity of the composite increases.
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105 **Fig 2: Effect of filler volume ratio on compression and hardness strength**
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109 **Fig 3: Water absorption behaviour of composites as a function of filler volume**
110 **fraction and time of immersion**

111 112 **3.1.1 Morphological study**

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114 The morphologies of the composite samples by SEM with EDS are shown in Fig 4, Particles
115 are well wetted by the polymer, analysis clearly showed differences in morphology of the
116 composite produced by varying the wood particle contents. The microstructure revealed that
117 there were small discontinuities and a reasonably uniform distribution of wood particles in
118 the LDPE matrix. The EDS analyses show that there are no chemical interfacial reactions
119 between the wood particles and the LDPE. This is as a result of the temperature of
120 processing that was not high enough to cause any chemical reactions. The major elements
121 revealed by the EDS are C and O. These elements are the major functional group in the
122 wood particles.
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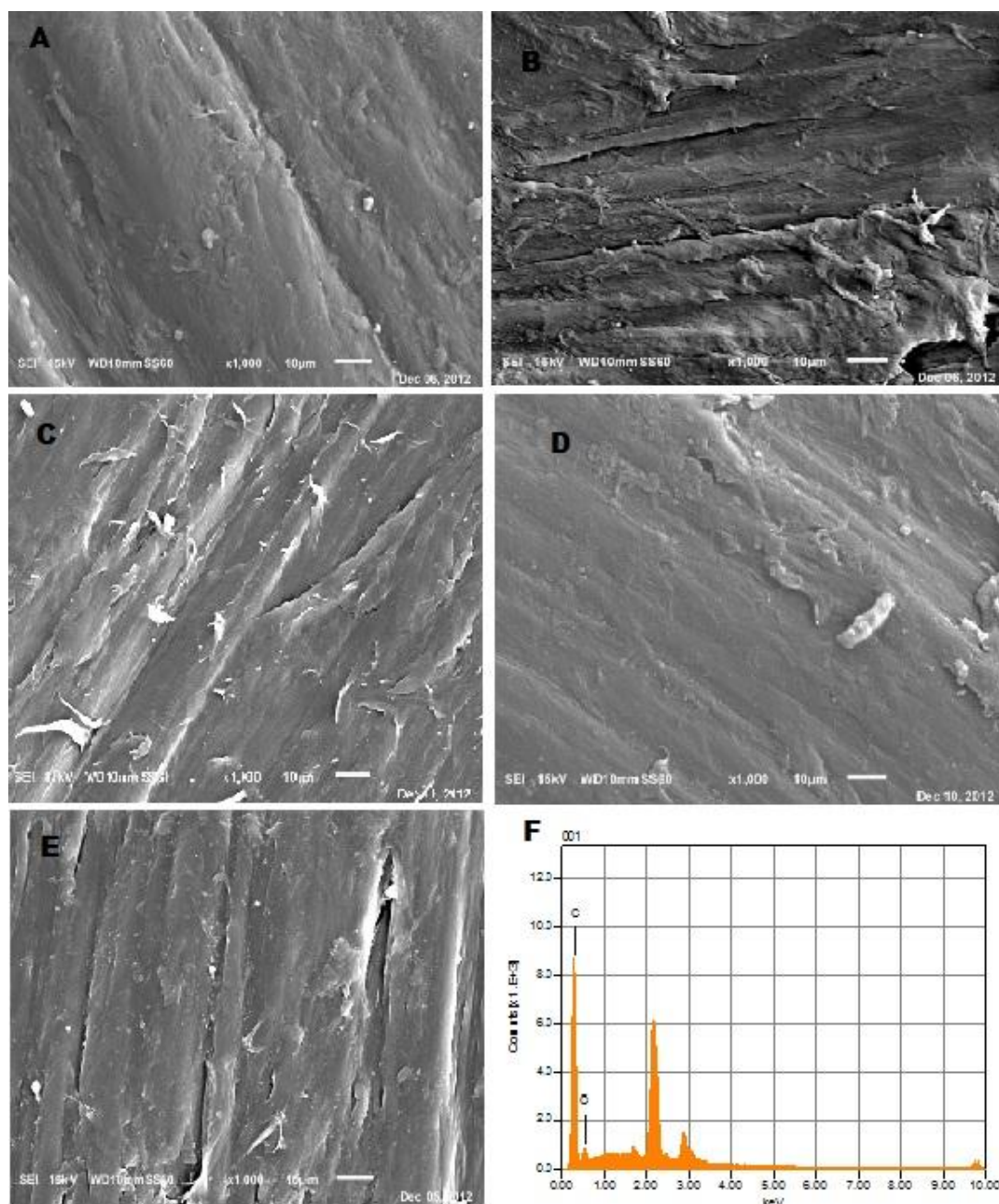


Fig 4: SEM micrographs of composites (A) 20%, (B) 30%, (C) 40%, (D) 50% (E) 60%, (F) EDS

4. CONCLUSION

wood waste as reinforcing filler in low LDPE has be fabricated, The wood particles which have high strength and modulus with good adhesion and uniform dispersion has impart better mechanical properties to the base polymer. Morphological studies has revealed that there is good dispersion of filler in the polymer matrix, hence, while fabricating a composite

of specific requirements, there is a need for the choice of appropriate filler material and for optimizing its content in the composite system.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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