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Journal Name:	American Chemical Science Journal
Manuscript Number:	2013_ACSj_5637
Title of the Manuscript:	Mechanical Properties of Wood Waste Reinforced Polymer Matrix Composites
Type of the Article	Research Paper

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PART 1: Review Comments

	Reviewer's comment Revise and Resubmit	Author's comment (if agreed with reviewer, correct the manuscript and highlight that part in the manuscript. It is mandatory that authors should write his/her feedback here)
Compulsory REVISION comments	This research work is an investigation into the mechanical properties of polymer matrix composites (PMC) produced by the use of wood waste. Low density polyethylene polymeric material was reinforced with sawdust from African teak as a filler, and Sodium hydroxide as the binder. The composites were fabricated by a compression moulding technique; composites with amounts of wood waste ranging from 20, 30, 40, 50, and 60 wt. % were produced. Results indicated that 40% of wood waste was the optimum reinforcement. Increasing amount of reinforcement improves the strength and stiffness of the composites but decreases the impact strength. The results also suggested that the rate of water absorption of the composite was high in the first few hours and that the highest water absorption rate was observed with 60% reinforcement. Microstructural examination revealed that there were small discontinuities and a reasonably uniform distribution of wood particles in the polymer matrix. 9 Keywords: Wood waste, Polymer Matrix Composite, Mechanical Properties, African <i>Teak</i> 10 11 12 1. INTRODUCTION 13	1. Low density “polyethylene polymeric material” polyethylene is a polymeric material, using this statement will amount to repetition 2. Line 73 (explain the difference to the fibres sample) all explanations regarding the preparation of wood waste as filler has been stated in material and methods 3. Line 85 and 95. The samples for the different test were prepared in accordance with ASTM standard for each test, which has been stated in 76-78. ASTM standards includes the dimensions, type of equipment and procedure for carrying out sample testing 4. All other corrections will be made



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	14 Composite is a material formed with two or more components, combined as a macroscopic 15 structural unit with one component as the continuous matrix, and the other as thefiller or 16 the reinforcement. Normally, the matrix is the material that holds the reinforcement together 17 and has lower strength than that of the reinforcing material. In the plastic based composites, the 18 polymer, the thermoplastic or the thermoset materialacts as a matrix and the particles of wood or any other natural 19 particles act as the filler. The reinforcing particles form the main load-carrying component in the 20 composites. It provides high strength and high stiffness as well as resistance to bending and 21 breaking under the applied stress. Interfacial bonding between the fillers and the matrix provides the 22 key mechanism of transfer of stress from the matrix to the fillers. 23 Investigations on polymer-based composite materials have opened new routes for polymer 24 formulations and have allowed the production of new composites with optimal properties for 25 specific applications [1, 2]. The production of polymer matrix composites reinforced with	
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	26 wood flour is an established technology [3-5]. And in order to achieve the required 27 combination of properties, interfacial interactions are often modified in these composites. 28 Interfacial adhesion can be achieved by the chemical modification of the wood, by 29 surface coating or by the introduction of a coupling agent. The particle size of wood 30 flour that is most often used for the reinforcement of plastics is large and the particles easily debond 31 when the composite is subjected to stresses that could lead to the formation of large voids. A number of 32 natural occurring fillers and fibers used in composites have been studied over the years. These include 33 wood fillers [3-6], wheat straw, almond husk, ash rice husk [7, 8], pineapple leaf, [9] coconut 34 fruit fibers, wood based filler derived from oil palm wood flour [10] etc. These fillers introduce 35 some advantages compared to traditional inorganic fillers, including their renewable nature, 36 low density, non-abrasive properties, reasonable strength, and stiffness [11]. 37 Using a natural filler to reinforce composite	
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	materials offers the following benefits 38 compared to mineral filler [12, 13];the natural filler is strong and rigid, light weight, environmental friendly, 39 economical, renewable, and offers an abundant resource. However,natural fillers have the disadvantage of 40 degradation by moisture, poor surface adhesion to hydrophobic polymers, non-uniform filler 41 sizes, they are not suitable for high temperature applications[14] etc. The objective of this 42 research work is therefore to investigate the mechanical, the water absorption, and themicrostructural 43 properties of low density polyethylene wood wastereinforced composite material. 44 45 2. MATERIAL AND METHODS 46 2.1 Preparation of Wood Reinforcement 47 48 Wood samples were collected from African teak from a wood mill in Bida, 49 Nigeria. The samples were sun-dried for two days to remove excess moisture, 50 soaked in hot water (100°C) for 1 hour, washed thoroughly, and air-dried for three 51 days at room temperature. They were then reduced	
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	to irregularly formed particles 1 to 2 mm 52 in size in a plastic mill equipped with two rotating knives. The sawdust particle size, the time of 53 alkaline treatment, the compression moulding parameters (time, pressure, and temperature), 54 the concentration of the NaOH solution, and the HCl acid solution, were all held constant while only the 55 wood sample content was varied. [15] 56 57 2.1.1 Chemical Treatment of Wood Reinforcement 58 59 25g of a sample (state size and type) were introduced into a 150 ml solution of 20% NaOH and stirred thoroughly 60 with a mechanical stirrer for 30 minutes. The mixture was next filtered and the residue was 61 dissolved into a 100 ml of prepared diluted hydrochloric acid to remove excess NaOH. The 62 mixtures were stirred, filtered and the residues were collected. The treated samples were 63 thoroughly washed five times with distilled water [16]. The treated fibre samples (are these different to the samples above?) were air 64 dried at room temperature for three days followed by drying in an oven at 105°C. (the rest are not needed) 65	
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	66 67 68 2.1.1.1 Compounding of Wood Polymer Composites 69 70 A 200 ton capacity compression moulding machine was used to compound the wood 71 polymer composites. In the initial stages, the female part of the mould was fixed on the carrier seat of the 72 machine. The LDPE (give the full description into brackets) was poured into the oven system where it was melted and maintained 73 at 180°C. At this stage the polymer was ready and the mixing of the wood particles (explain the difference to the fibres sample) with the 74 molten polymer took place inside the oven system at temperature 180°C and pressure 75 40kg/cm² for 10 minutes. The procedure was repeated for the various amounts of 76 wood reinforcement. Impact testing was carried out according to ASTM D256. 77 Compression testing was carried out according to ASTM D695. Water absorption testing was carried out according to 78 ASTM D570. Finally, a scanning electron microscope, JEOL 6010LA. was used for surface 79 characterisation.	
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	80 81 3. RESULTS AND DISCUSSION 82 83 3.1 Mechanical Properties 84 85 Fig. 1 indicates that as the particle (explain what sample type was used here) content increases, the composite becomes more 86 stiff and less ductile. It is evident that as the particle content is increased beyond 60% reinforcement, the 87 particles may not interact with the polymer matrix and the interfacial adhesion that is responsible for 88 the composite stiffness and strength would be much lower as the particles 89 agglomerate. 95 Fig. 2 shows how wood (explain what sample type was used here) content affects the compressive strength of PMCs (give the full name into brackets). Increasing fiber 96 reinforcement improves the strength and stiffness of the composite. The hardness strength 97 also shows a slight increase as the filler volume ratio increases, and gradually decreases above 98 50 wt%. The water absorption test results are shown in Fig 3. It is clear from this Figure that the composites	
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	99 absorb water at very fast rates in the initial stages and a saturation level was reached in each curve. 100 It was also observed that as the filler volume fraction 101 increases, the water absorption rate of the composite increases. From Fig. 3 can calculate a diffusion coefficient (D) and a solubility coefficient (C). Need to plot $(W_t - W_o)/W_o$ (g/100g) against $2t_d^{1/2}/t$ ($\text{sec}^{1/2}/\text{mm}$), then the slope of the linear part gives D. To do this see references 1) P. Frantzis, Environmental Attack on Adhesive Joints. Part III: Mechanisms of Failure, JSME International Journal, Series A, Vol. 41, No. 3, 1998, pp 405-415, and 2) P. Frantzis. Crumb Rubber-Bitumen Interactions: Diffusion of Bitumen into Rubber, ASCE Journal of Materials in Civil Engineering, Vol. 16, No. 4, 2004, pp 387-390. I think that at least a diffusion coefficient should be calculated for each curve in Fig.3 to give a more complete picture of the water absorption process. To calculate a solubility coefficient requires the writing of a computer programme and therefore this may be omitted at this stage. The authors can then make a short statement with their results for D for the wood/polymer system and analogous systems like absorption of water into rubber/epoxy (reference 1) and absorption of bitumen into rubber (reference 2). 112 3.1.1 Microstructural characterisation 113 114 Fig 4 shows micrographs of the surfaces of	The scope of this research was not a detain water absorption study, however, the authors are currently working on a comprehensive detained study of water absorption properties of polymer composite reinforce with wood waste from Africa treak tree, at different conditions i.e. effect of temperature, effect different chemical modification of filler etc, mathematical models will be applied diffusion coefficient and others will be determine, which hopefully will be published in this journal.
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	composite samples using SEM with EDS (need to state how the surfaces to be viewed were obtained). Particles 115 are well wetted by the polymer and the analysis clearly showed differences in microstructure of the 116 composite produced by varying the wood particle content. The microstructure revealed that 117 there were small discontinuities and a reasonably uniform distribution of wood particles in 118 the LDPE matrix. EDS analyses show that there are no chemical interfacial reactions 119 between the wood particles and the LDPE. This was considered to be due to the processing temperature 120 that was not high enough to cause any chemical reactions. The major elements 121 revealed by EDS are C (Carbon) and O (Oxygen). These elements are the major functional group in the 122 wood particles. 129 4. CONCLUSION 130 131 This work relates to wood waste as a reinforcing filler in low LDPE (give the full name into brackets). The wood particles that 132 have high strength and high modulus coupled with	
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	good adhesion and uniform dispersion into the matrix materialgive the 133 better mechanical properties compared to the unreinforcedpolymeric material. Microstructural studies have revealed that 134 there is a good dispersion of the filler into the polymer matrix.Composite fabrication 135 for a specific applicationrequires the appropriate filler materialto include 136 optimizing its content in the composite system.	
<u>Minor</u> REVISION comments		
<u>Optional/General</u>comments		