Scientific and Commercial View On the Sal Wood Flour Polymer and Neem Wood Flour Composites

Askari Imam Khan[1], Dr. Praveen Kumar[2]

[1]Research Scholar, Sardar Patel University, Balaghat (M.P)
[2]Research Supervisor, Sardar Patel University, Balaghat (M.P)

Abstract

Synthetic fibre reinforced polymer composites are the backbone of today's industrial composites. The size of the leftovers might range from powder to rice grains. The quality of wood flour varies with the kind of wood processing used. Here, the effect of mesh size on mechanical characteristics was studied across three different concentrations of wood flour. A matrix of heavy polyethylene with the code 5218, melt flow index 18 g/10 min, and density 0.959 g/cm3 was produced by Arak Petrochemical Company (Tehran, Iran). The gauge length for this tensile test was 100 mm, and the rate of tension was 10 mm/min. In order to be considered statistically significant, the percentage of the association that may be attributed to chance must be below 5%. It is completely arbitrary that 95% has been selected as the threshold. Possible explanation: it's made out of thermoset plastic, which isn't as durable as thermoplastic.

Keywords: *Wood Flour Size, Neem Wood Flour, Polymer, Mechanical Properties and Composites.*

1. INTRODUCTION

Since humans first began experimenting with composites, they have been seen as a viable option to replace traditional metals and other less desirable materials in many industrial applications due to their superior qualities. Metal has been phased out of most Engineering applications in favor of composite materials. Polymer composites reinforced with synthetic fibers are the primary building blocks of the industrial composites market. Synthetic fibres are the superior composite material, but they have the drawback of not being biodegradable and are a major source of carbon dioxide emissions. Scientists are shifting their focus away from synthetic fibre and toward natural fibre because of the latter's environmental friendliness. It's easy to find, inexpensive, and good for the planet to use natural fibres. Polymer composites based on natural fibres are also produced, although they have a very narrow range of potential uses outside of lightweight consumer goods and domestic fixtures. Possibly this is because natural fibre has a lower mechanical strength than synthetic fibre. Fillers such as calcium carbonate (CaCO3), kaolin (hydrous aluminium silicates), alumina trihydrate (Al2O3), calcium sulphate (CaSO4), graphite silica (SiO2), and clay (Ceramica sphaerica) are now commonly used in conjunction with fibre to reinforce polymer matrices. When added to composites, fillers boost their strength, hardness, wear resistance, electrical conductivity, and thermal conductivity. The term "wood flour" refers to the natural byproduct that is left behind when lumber is sawed. This study elucidated the wood flour reinforced polymer composite. The wood flooring was chemically treated to improve its qualities and ensure it was compatible with the polymer matrix.

As a byproduct of milling or peeling wood, wood flour is a useful byproduct. The leftovers might be a fine powder or larger pieces, about the size of rice grains. The wood-processing method has a significant impact on the final product's quality. It's possible for it to be of a low quality or a high quality. Hardwood trees, such as teak, oak, poplar, etc., produce high-quality wood flour, while softwood trees, such as pine, fir, cedar, larch, spruce, etc., produce low-quality wood flour. Conversely, angiosperm trees are those that are evergreen and have narrower leaves than hardwood trees. Whereas hardwood is utilized for more weighty construction and furnishings, softwood is more often used for building materials, furniture, moulding, door manufacturing, etc. Wood flour typically comes with dirt, bark, and other foreign matters that must be removed before the wood can be brought into contact with resin to create the composite. The wood's hydrophilic characteristics are to blame for this. The mechanical characteristics of a composite are also affected by the mesh size and fibre aspect ratio. Wood flour has traditionally been used with phenol formaldehyde, but it is now also used as a filler material with a coupling agent in polymers such as polypropylene, polystyrene, polyethylene, polyamides, and polyesters to improve their mechanical properties.

2. REVIEW OF LITRATURE

Geeta Pokhrel et.al (2021) Part I and this current Part II of this paper series investigate the use of an alternative wood feedstock, i.e. pellets, in the production of wood-plastic composites (WPCs), with the goal of reducing the transportation costs of raw materials. This research began with a report on the properties of wood flour and wood pellets made from secondary processing mill leftovers. The second section presents data on the physical and mechanical characteristics of WPCs based on polypropylene (PP) that were produced using wood flour and wood pellets as feedstocks. Using four different types of wood (white cedar, white pine, spruce-fir, and red maple) and either the coupling agent maleic anhydride polypropylene or its absence, WPCs were fabricated. Without MAPP, the composition was 20% wood filler and 80% PP by weight, but with MAPP, the percentages were 20% wood filler, 78% PP, and 2% MAPP, respectively. Wood flour and pulverised wood pellets both had a comparable particle distribution in the PP polymer matrix, as shown in fluorescent photos. Ground wood pellets in the PP matrix led to better particle dispersion. The average density, tensile strength, and tensile modulus of composites made from wood pellets were all higher than those made from wood flour, while the average impact strength was lower. The control composites made from pellets had better flexural properties than the composites made from wood flour, while the MAPP composites had worse flexural properties. However, variations in mechanical properties were minimal (0.5-10%) among different WPC formulations. Wood flour and wood pellet composites were shown to have comparable material property values in statistical analyses. Using wood pellets instead of wood flour improved the WPC characteristics in several applications. WPC makers and customers would benefit from a decrease in transportation costs for wood pellet feedstocks and a similarity in material qualities between WPCs made from wood flour and those made from wood pellets, as opposed to only wood pellets.

Yuanbin Ma,Hui et.al (2019) In part because of their recyclable quality and their ease of processing, wood-plastic composites have recently garnered a lot of attention from the public. Nano silica has further applications, such as reinforcing filler for wood-plastic composites. However, getting a uniform nano silica dispersion across wood-plastic composites is challenging. Wood flour (WF) was modified on-site using alkali treatment and the sol-gel technique to create a WF/silica hybrid, which was then utilised to make polypropylene-based wood-plastic composites with added reinforcement. Infrared spectroscopy, scanning electron microscopy, and thermogravimetric analysis were used to investigate the physicochemical parameters of the WF/silica hybrid. Wood-plastic composites based on polypropylene were then studied with regards to their mechanical characteristics, Vicat softening temperature, oxidation induction time, and thermal breakdown behaviour. Test outcomes were compared to those of wood-plastic composites made from a combination of polypropylene and nano silica. When comparing wood-plastic composites filled with commercial silica to those filled with hybrid filler, you'll find that the latter provide superior mechanical capabilities and thermal stability. Hybrid's inclusion helps boost the composites' thermal oxygen resistance as well. We hope that our effort may provide some fresh ideas for making high-performance wood-plastic composites.

Nagamadhu M et.al (2018) This experimental research looks at how different stacking orders of wood veneers affect the mechanical characteristics of neem wood polymer composite (WPC). Samples of wood laminates were made using the standard hand layup method in a mold, cured under pressure at room temperature, and then post cured at higher temperatures. Tensile, flexural, and impact tests were first performed to determine the effects of fibre weight fraction on mechanical characteristics. A higher fibre weight fraction results in improved mechanical characteristics. Additionally, neem wood's stacking order is significant. As it greatly affects the material's mechanical qualities. When compared to other sequences (90°/90°, 0°/0°, 45°/90°, 45°/45°), the results showed that 0°/0° WPC exhibited the highest mechanical properties. To determine what chemicals were present in both raw neem wood and the neem wood epoxy composite, a technique called Fourier Transform Infrared Spectroscopy (FTIR) Analysis was used. Scanning electron microscopy was used to look at the microstructure of raw/neat neem wood and the interfacial bonding characteristics of neem wood composite.

M. Nagamadhu,et.al (2020) Many wood structural applications employ neem wood veneer as the primary material. Preparation of neem wood polymer composites (NWPC) used to investigate the impact of weight fraction, stacking sequence, and interfacial bonding between neem wood veneer and epoxy material. Samples of NWPC were made by normal compression moulding, and their thermo-mechanical characteristics were studied using a dynamic mechanical analyzer from 30 to 180 degrees Celsius. There was a notable correlation between the weight percentage of wood veneer and the NWPC samples' storage (G') and loss (G"). Epoxy is an excellent interfacial bonding agent, which helps it strengthen multilayered wood polymer composites. Despite this, G' and G" rise along the wood fibre direction of the stack, whereas the transfer direction has almost little load bearing capability. By switching its orientation, wood veneer gained superior characteristics in both directions. In addition, the interfacial bonding efficiency is clearly shown by scanning electron microscopy (SEM).

3. MATHODOLOGY

The effect of mesh size on mechanical characteristics was studied across three different concentrations of wood floor. Particle size was standardized and the target size was attained by classification using a vibrating sieve. Coarse, medium, and fine reinforcements, with +30/40, +70/80, and +100/120, respectively, were investigated. Only the +100/120 mesh size was taken into account for the study of the impact of injection moulding temperature on mechanical qualities. After 24 hours in a 100 C oven, the grains' humidity had dropped to 2%.

Matrix material was Arak Petrochemical Company (Tehran, Iran) code 5218 heavy polyethylene, which has a melt flow index of 18 g/10 min and a density of 0.959 g/cm3. Krangin Company (Karaj, Iran) maleic anhydride-grafted-polyethylene (MAPE) was also employed to ensure compatibility between the reinforcement and matrix. Both the melt flow index (7 g/10 min) and the density (0.965 gr/cm3) are critical characteristics of MAPE. The supplement was taken at a steady rate of 3% by weight.

In many structural applications, 1.5–2.5 mm thick Neem wood veneer is employed as the core material. The Neem or Margosa is a kind of evergreen tree that is related to mahogany in the plant kingdom. It has an average density of 541 Kg/m3 and is from the Meliaceae family. It may be found in India. Neem wood veneers have been procured from Maruthi Plywood, Nelamangala, Bangalore.

Mechanical Properties

For this test, we used a strip of 160 mm in length, 12.5 mm in width, and 4 mm in thickness to measure the tensile strength in accordance with ASTM D638-03. The gauge length for the tensile test was 100 mm, and the rate of tension was 10 mm/min. Flexural tests were performed with a width of 12.7 mm, a length of 127 mm, a thickness of 4 mm, a cross head speed of 2 mm/min, and a span length of 90 mm, all in accordance with the ASTM D790 standard. Using an Izod Impact tester measuring 12.7 mm in width, 64 mm in length, and 4 mm in thickness, we ran an impact test to the specifications of ASTM D 256.

Table 1: Representation of Stacking Sequence of Neem Wood to Evaluate Mechanical Properties

Sample Number	Weight fraction (W_n:M)	Stacking Sequence of Neem wood veneer	Representation/Codes used to identify samples
1	27:75	0°	Type 1 (T1)
2	55:45	0°/0°	Type 2 (T2)
3		90°/90°	Type 3 (T3)
4		0°/90°	Type 4 (T4)
5		90°/0°	Type 5 (T5)
6		90°/45°	Type 6 (T6)
7		45°/90°	Type 7 (T7)
8		-45°/-45°	Type 8 (T8)

Table 1 specifies Neem wood ply stacking angles and the sequence of the lay-up.

4. DATA ANALYSIS

Effect of Mesh Dimensions on Mechanical Properties

Dimensions of Flour

Table 2 shows the average length, diameter, and aspect ratio of wood flour in three categories of +30/−40, +70/−80, and +100/−120 meshes.

Table 2. Mean Length, Diameter, and Aspect Ratio of Wood Flour Dimensions.

Mesh Dimensions	Length (μm)	Diameter (μm)	Aspect Ratio (l/d)	Specimen
+30/−40	3239.99	1060.01	3.07	1
+70/−80	646.13	208.1	3.16	2
+100/−120	243.4	158.5	1.6	3, 4, 5

As can be seen in Table 2, as the mesh size is decreased, the aspect ratio of wood flour increases from +30/40 to +70/80 and then decreases to +100/120.

Experimental Test Results

Table 3 displays the results of a variance analysis of the effect of mesh dimensions (aspect ratio) on the flexural strength, modulus, tensile strength, and impact energy of the composites. Table 3 shows that the effect of mesh size was substantial on impact energy, flexural and tensile strengths, but not on the other properties tested. It's considered statistically significant when the chance of an accident explaining the relationship is less than 5%. It is completely arbitrary that 95% has been selected as the threshold.

Table 3. Variance Analysis of Wood Flour Size Effect on The Mechanical Properties (P-Values).

Mechanical Properties		*p*-Value
Tensile (MPa)	Strength	0.000 **
	Modulus	0.118
Flexural (MPa)	Strength	0.012 *
	Modulus	0.281
Impact energy (J)		0.003 *

* $p < 0.05$; ** $p < 0.001$

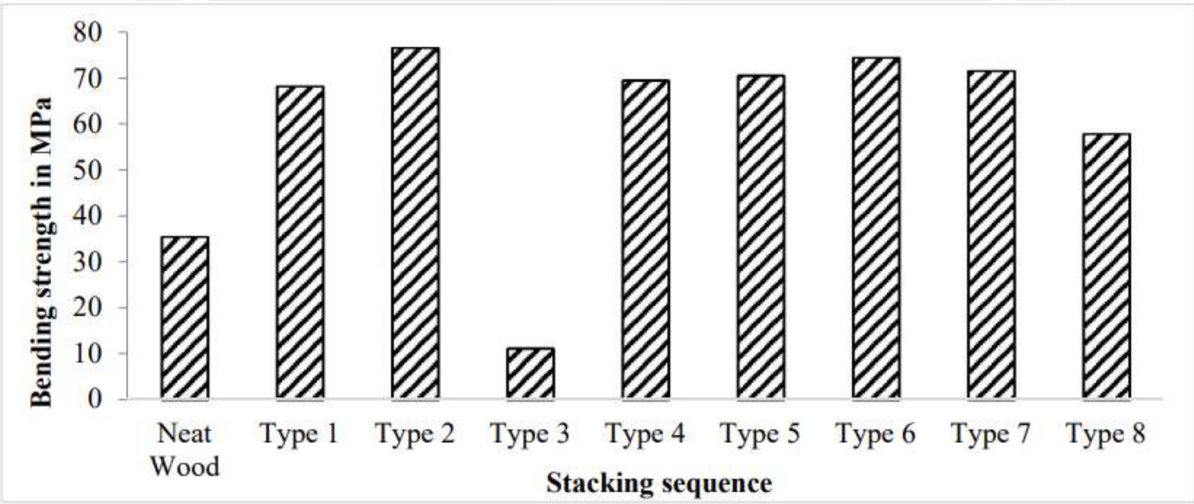

Figure 1. Effect of flexural strength of neem wood composite on stacking sequence

The bending strength of WPC is shown in Figure 1. Aside from T3 composites, neat wood fails under a far lower stress than other materials. A possible explanation for the low load at which T3 composite fails is that its bending load axis and fibre loading axis are coincident. Since wood fibres are rather weak against bending, the matrix material must step up to the plate. There is little to no variation between T4, T5, T6, and T7 variants of the composite under flexural stress. This may be because all of these composites have one 90° veneer. The flexural test result strongly indicates that reinforcing material is crucial. However, resin impact was evaluated only in T3 based composite. However, the interfacial bonding between the neem wood and the matrix is significantly impacted by the resin substance. In other words, this demonstrates that WPC fails in a way that does not involve de-lamination of the individual laminates.

5. WOOD FLOUR

The availability of wood is guaranteed everywhere on Earth. Its prevalence varies greatly depending on location, yet it can be found almost everywhere on Earth. Roughly half of all softwood comes from the Commonwealth of Independent States (CIS). This is because pine, Bruce, and balsa are typical examples of softwoods found in the evergreen forest. Typically, nations like Estonia, Lithuania, Armenia, Ukraine, Romania, etc., are where one would find a forest of this kind. After Europe and Asia, North America is the third-largest country in terms of softwood. South American nations, followed by those in Asia and North America, are rich in hardwood because their woods are both temperate and tropical. Hardwoods such as oak, maple, birch, etc. are abundant in these areas.

Table 1 and Table 2 detail the mechanical and physical characteristics of many well-known species of wood. You may often categories wood as either softwood or hardwood. The term "softwoods" refers to a group of coniferous trees that includes cedar, fir, pines, spruce, and larch and is also known as "gymnosperm." These trees are used in the construction of windows, doors, and other architectural elements. Contrarily, hardwoods, also known as angiosperms, are characterized by their broader leaves and thrive in deciduous climates. Common examples of hardwoods include maple, oak, cherry, teak, etc. Hardwoods are often utilized in the building of bridges, dam components, and other large-scale structures.

Table 4. Properties of softwood

Species	Modulus of elasticity(psi)	Shear strength(psi)	Compression parallel to grain (psi)	Compression perpendicular to the grain(psi)	Modulus of rupture(psi)	Specific gravity
Pine, red	1281	686	2730	259	820	0.42
Fir, grand	1250	739	2939	475	5839	0.35
Spruce, Engelmann	1029	637	2180	197	705	0.33
Redwood	1177	803	4210	424	500	0.39
Fir, white	1161	756	2902	491	5854	0.37
Douglas fir, coast type	1560	904	3784	700	7665	0.45
Larch, western	1458	869	3756	676	7652	0.48
Pine, sugar	1032	718	2459	214	893	0.34
Pine, longleaf	1586	1041	4321	804	8538	0.54
Pine, lodgepole	1076	685	2610	252	490	0.39
Cedar, eastern red	649	1008	3570	700	30	0.46
Fir, balsam	1251	662	2631	187	517	0.32
Pine, ponderosa	997	704	2450	282	130	0.39
Fir, noble	1380	802	3013	478	6169	0.37
Cedar, western red	939	771	2774	244	184	0.31
Pine, western white	1193	677	2434	192	688	0.35
Pine, shortleaf	1388	905	3527	573	7435	0.47
Spruce, black	1382	739	2836	242	118	0.38
Pine, loblolly	1402	863	3511	661	7300	0.47
Spruce, Sitka	1230	757	2670	279	660	0.38
Fir, Pacific silver	1420	746	3142	414	6410	0.39
Hemlock, western	1307	864	3364	457	6637	0.42
Hemlock, eastern	1073	848	3080	359	420	0.39

Wood flour is a common phrase used across the world to describe wood scraps (WF). When coupled with a gum-like adhesive, WF wastes are often used to fill the spaces between cardboard sheets, and if supplies are plentiful, they may also be utilized as decking and roofing materials in places where a lot of wood is removed. Since WF is biodegradable natural dust, its limited use has not posed a serious threat to the environment, but disposing of the massive amounts that have accumulated in the Earth's crust has become a pressing issue.

Table 5. Properties of hardwood

Species	Modulus of elasticity(psi)	Compression perpendicular to the grain (psi)	Compression parallel to grain (psi)	Shear strength(psi)	Modulus of rupture(psi)	Specific gravity
Yellow-poplar	1222	269	2660	792	950	0.4
Ash, white	1436	667	3990	1354	500	0.54
Sweetgum	1201	367	3040	991	110	0.46
Beech, American	1381	544	3550	1288	570	0.57
Oak, white	1246	671	3560	1249	300	0.6
Cottonwood, eastern	1013	196	2280	682	260	0.37
Oak, northern red	1353	614	3440	1214	300	0.56
Sycamore, American	1065	365	2920	996	470	0.46
Maple, silver	943	369	2490	1053	820	0.44
Tupelo, black	1031	485	3040	1098	40	0.47
Hackberry	954	399	2650	1070	480	0.49
Alder, red	1167	250	2960	770	540	0.38
Basswood, American	1038	170	2220	599	960	0.32
Birch, paper	1170	273	2360	836	380	0.48
Elm, American	1114	355	2910	1002	190	0.46
Maple, sugar	1546	645	4020	1465	480	0.57
Oak, southern red	1141	547	3030	934	920	0.53

Table 3 shows the impact strength of a number of polymers with and without WF. Table 3 details the impact of many compatibilizer, fire retardant, and lubricant options. When PP is cross-linked, the resulting impact strength is 209.5 J/m at 70% WF, while HDPE-based WF composites only show 80 J/m at 40% WF. In comparison to high-density polyethylene (HDPE), polyvinyl chloride (PVC), and polyester (PET), PP-based composites have much lower impact strength. The fact that it's made of thermoset plastic, which isn't as durable as thermoplastic, might be to blame. In the meanwhile, Table 3 displays the impact strength of treated and untreated polymers based WF composites with varied WF concentration. Maximum impact strength is achieved with the treatment of WF and chopped carbon fibre, as shown in Table 6.

Table 6. Impact strength of WF-polymer composites

S. No.	Matrix (Wt. %)	Wood flour (Wt. %)	Impact strength	Comment	Application
1	XLPE (68%)	30	209.5 J/m	Polymer was cross linked with WF via silane technology	Window lining
2	HDPE (70%)	30	10.5 KJ/m^2	Polymer was cross linked with WF via silane technology along with 4% fire retardant	High strength cardboards used in marine
3	PP (58%)	40	46 J/m	PP was treated with 2 wt. % of Maleaic Anhydride	Doors and decking
4	PP (58%)	40	36 J/m	PP was treated with 2 wt. % of Maleaic Anhydride along with treatment of WF by 1% zinc borate	Doors and decking
5	HDPE (55%)	35	4.2 KJ/m^2	5% mineral particles were added in the composite	Boards and lumber
6	PP (44%)	47	5.57 J/m	3 wt. % malaeic anhydride, 4% fire retardant and 2% lubricant were added in the composite	Parts for marine engineering
7	HDPE (40%)	60	80 J/m	Sodium ionomer was added @ 40% of the total volume of composite	Boards and lumber
8	PPC (80%)	20	14.2KJ/m^2	PPC was grafted with maleaic anhydride	Frames and trims
9	Polyester (75%)	10	13 J	15% gum rosin was used to enhanced the interfacial bonding	Building materials
10	HDPE (40%)	58	59 J/m	2 wt. % MAPE was used and effect of WF geometry of mesh size 20 was analyzed	Automotive industries
11	HDPE (40%)	58	63 J/m	2 wt. % MAPE was used and effect of WF geometry of mesh size 60 was analyzed	Automotive industries
12	PP (40%)	30	6.25 KJ/m^2 (un notched), 1.5 KJ/m^2 notched	Fire retardant @ 30% was used in the study	Furnishing materials
13	PVC (70%)	30	26.5 KJ/m^2	WF was treated with 2% lignin amine	packaging
14	PVC (70%)	30	26 KJ/m^2	Wood flour was treated with 1% lignin amine	packaging
15	HDPE (70%)	30	1.12 KJ/m^2	Fire retardant was used @ 4%	
16	Recycled PP (39%)	50	3.45 KJ/m^2	WF was treated with 9 wt. % of ethylene acetate	Equipment's for showcase
17	PP (70%)	25	26.5 J/m	Significant improvement of about 39.4% was observed with the addition of 5% MAPP	Doors and panels
18	PP (52%)	40	20 J/m	Treated with 5% MAPP along with the addition of 3% organ clay	Doors and panels
19	Recycled Polystyrene (50%)	50	5.2 J/m	23.8% increase was observed in impact strength due to recycling of Polystyrene	Equipment for showcase
20	PP (22%)	63	3.3 KJ/m^2	3% MAPP, 2% lubricant was used along with 10 wt. % of chopped carbon fiber leads to reduction in 19. 51% in impact strength	Chairs and tables
21	PP (22%)	63	3.8 KJ/m^2	3% MAPP, 2% lubricant was used along with 10 wt. % of fiber leads to reduction in 7.31% in impact strength	Chairs and tables

6. CONCLUSION

This article clarified the topic of wood flour reinforced polymer composites. To improve its qualities and ensure it was compatible with the polymer matrix, a chemical treatment was done to the wood floor. Wood flour quality might change depending on the method of wood processing. The quality might vary widely. Wood flour of lower quality is a byproduct of softwoods including pine, fir, cedar, larch, spruce, etc. After drying the grains in an oven at 100 degrees Celsius for 24 hours, their relative humidity dropped to 2%. MAPE has a melt flow index of 7 g/10 min and a density of 0.965 gr/cm3; these are its primary characteristics. This additive was utilized at a steady 3 weight percent. We have sourced our Neem wood veneers from Maruthi Plywood in Nelamangala, Bangalore. About half (50%) of the construction materials are softwood. This is due to the fact that pine, Bruce, and balsa—all softwoods—come from the evergreen forest. If there is a considerable quantity of WF available, it is often utilized as roofing and decking materials in places where a lot of wood is removed for construction. This is likely because to the waste's thermoset plastic properties, which make it weaker than thermoplastic.

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