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Investigation on the use of nanoclay against white rot fungi

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Abstract

Background and Objective *:* Nanoclays as reinforcement filler for adhesives is being established but their efficacy against whiterot fungus in particle board is not much explored**.** The present aim of the study was to explore the usage of nanoclay Nanomer PGV against White rot fungus in particle board. ***Methodology*** : For the study, eight single layer particle board particle board made using (0.25 and 0.5 % wt)nanoclay reinforced Urea formaldehyde resin (UF)and melamine urea formaldehyde resin (MUF)was compared with control boards and boards made using 0.5 % boric acid. Dispersion of nanoclay in the urea formaldehyde and melamine urea formaldehyde resin was done by mechanical mixing and it was characterised using Xray diffraction. Efficacy of nanoclay against white rot fungus was studied using Agar block method as per IS: 4873. ***Results:***The intensity peak of Nanoclay disappeared after being dispersed into the UF resin and MUF resin by mechanical mixing. This indicated that the UF resin or MUF resin was able to enter the interlayer space of Nanomer PGV, hence exfoliated. From the results of the efficacy test it was found that the nanoclay 0.25 % and 0.5 % concentration satisfied the attack of white rot in case of UF and MUF resin bonded particle board. ***Conclusion***: Nano clay has shown usefull effect on controlling the average weight loss due to white rot fungus in particle board.

Keywords: Nanomer PGV, Nanoclay, particle board, White rot fungus

1. Introduction

Wood-based composite products are commonly substituted for solid wood in today's building structures. Non-structural engineered wood composites based on oriented strandboard (OSB), Particle board, medium density fiberboard (MDF) etc are now used in both interior and exterior applications[1]. The increasing use of low formaldehyde emission resin such as E1 grade Urea formaldehyde resin and melamine urea formaldehyde resin for the manufacture of particle board has led researchers to find ways to improve the durability of the products against bio deterioration agents[2]. Particle board is susceptible to wood decay fungi which can severely affects its economic value and usefulness.

White-rot causing fungi degrade all cell wall components including lignin. It is important to develop long protection methods during manufacturing process[3]. It has been reported that the strength in particle board is considerably reduced than the losses in fungus free samples, primarily due to the weakening of glue line by the fungi. Improving the durability of the board by preservative treatment is one way of extendending its end uses[4]. Using nanoclay to reinforce polymer based composite have raised great attention in the academic and industrial sectors. Because these materials have strong absorbability as well as high barrier property. Very limited work has been done regarding the usage of nanoclay as a preservative in particle board. Hence a study to explore the usage of nanoclay bentonite against white rot fungus in single layer particle board using urea formaldehyde and melamine urea formaldehyde resin has been taken up.

The effect of organo-modified montmorillonite (OMMT) loading on the natural durability properties of polypropylene/wood flour composites exposed to brown-rot fungi (*Coniophora puteana*) was studied.

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2. Materials and methods

Urea formaldehyde resin and melamine urea formaldehyde resin was synthesised for the manufacture of the single layered particle board. Properties of the resin used are as shown in table-I. Nanoclay used in the study was procured from M/S

Table I: Properties of the resin

Resin	UF	MUF
Flow time (sec)	21	19
Solids (%)	50	51
PH	8.0	8.5-9.0

Sigma Aldrich chemicals pvt ltd, Bangalore. Nanomer PGV is unmodified nanoclay with a bulk density of 600-1100 kg/m^3, having a micron size less than 25 and loss on drying < 18%. Nano clay (0, 0.25, 0.5, % wt) on the weight of the resin, was added at room temperature. Nano clay was added to the resin and the mixture was stirred using a mechanical stirrer at a rotation speed of 1000rpm for thorough dispersion. Hardener was then added into the resin for further 5 min mixing time. Wood species poplar (*Poplus deltoids*) was used in the study for the manufacture of Particle board measuring 0.3m ×0.3m ×12 mm with density of 750-800 kg m^{-3}.

2.1 Characterisation

To evaluate the degree of clay dispersion in polymer matrices, X ray diffraction was used. After mixing the nano clay to the resin the mixture was cured in a drying oven at 103^0 c for 24 hrs, removed from the oven and cooled .The samples were ground down to powder and mounted in the sample holders of D8 Focus (Bruker) X ray Diffractometer and scanned from 3 -15^0 with a step size of 0.04 and 0.8s /step. X ray radiation was generated by using a 35KV, 40mA cobalt radiation source. EDAX of the Nanoclay were analysed to know the chemical composition of the materials.

2.2 Manufacturing of Particle board

Particles of poplar species having slenderness ratio of 100-180 for core particles were dried to a moisture content of 2-3% before blending with the resin. The particles were blended with 10% resin on dry solid basis for particles. Nano clay and hardener were added to the resin as described previously for the boards **P1, P3, P5, and P6**. Formulations of the boards made are as shown in the **Table II**. For the boards P7 & P8, 0.5 % boric acid on the oven dry weight of the resin was added. Manually glue blended particles were placed into a mat forming box with base dimensions of 330mm x 330mm. Pre-pressing and compression of the particles were done by pressing a matching wooden plate on the mat in the forming box by applying manual pressure. Supporting rods to control the thickness to12mm were placed on either ends of the assembly. The assembly was then loaded into a hot press of size 350mm x 350mm wherein the temperature of the platens was maintained at 160 -165 °c for the manufacture of single layered particle board. Pressure of 24kgs/ sq cm (compression cycle) for 7 minutes and 10-12 kg/sq cm (curing cycle) for 5 minutes were employed for UF resin and MUF resin respectively. The boards were kept for stabilization for about 24 -48 hours to attain equilibrium moisture content and then trimmed. The trimmed boards were further dimensioned to required sizes and subjected after conditioning for testing.

2.3 Test against White rot (Agar block method)

A nutrient medium containing 20g of agar and 20g of malt extract in a litre of distilled water, autoclaved at 120^0 c for 20 minutes was taken in Kolle flask. The test blocks (**P1-P8**) were made of the size 50mm x 25 mm x 15mm. The whole set of flask were then incubated for 12 weeks at 27^0c .The test was carried as per IS: 4873[5].The oven dry weight of the samples after sterilising were incubated for 12 weeks .After the completion of 12 weeks, the samples were removed from the kolle flask and the mycelium adhering to it was cleaned by taking care not to remove the splinters of the particle board. The samples weight taken after incubation is considered as initial weight. The blocks were dried to constant weight to get a constant weight. The mean Percentage weight loss[5] was calculated as per IS: 4873. The result of the toxicity study has been tabulated in **Table III**.

3. Results and discussions

Analysis of chemical composition by EDAX reveals that Nanomer PGV (B) contains 32.34 mass percentage of silicon, 10 .11 of Aluminium and 2-3 % of sodium & magnesium as shown in **Figure I & II.**

Table II: Formulation of the boards

Particulars	P1	P2	P3	P4	P5	P6	P7	P8
Resin	MUF	MUF	MUF	UF	UF	UF	MUF	UF
Nanoclay (%)	0.25	-	0.5	-	0.25	0.5	-	-
Boric acid	-	-	-	-	-	-	0.5	0.5

Table III: Average weight loss of the samples

	Average weight loss	
Samples	**UF**	**MUF**
Nanoclay	(P5)9.32 (P6)7.68	(P1)9.34 (P3)8.07
Boric acid	(P8)15.39	(P7)10.95
Control	(P4)15.15	(P2)10.53

3.1 XRD analysis of the samples

The interlayer space between clay layers can be detected by XRD by a peak in the x-ray intensity at a characteristic angle and the inter-platelet distance calculated[6]. According to Bragg's law, the interlayer spacing (d) in nanoclays and the relative intercalation (RI) of the polymer in nanoclays can be determined using the following equations,[7] $n\lambda=2d\sin\theta$.Where n is the integer number of wavelength (n = 1); λ is the wavelength of X-ray; d is the actual interlayer or d-spacing of the clay in the matrix; θ is the diffraction angle corresponding to a specific intensity peak. From the Bragg Law, the lower peak diffraction angles indicate larger distances between the interlayers of nanoclay. The peak appearing at 6.478 corresponds to Nanomer PGV to a d spacing of 1.363 nm according to bragg equation .From the **Figure III a, b** for the UF/B and MUF/B system the (001) peak disappeared. This indicates that the

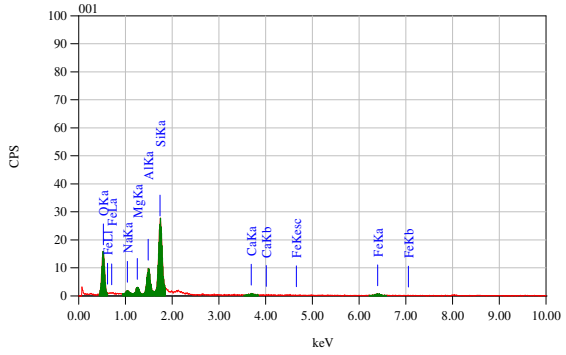


Figure I Chemical composition of Nanomer PGV

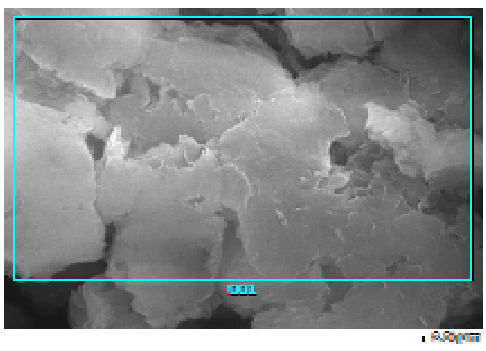
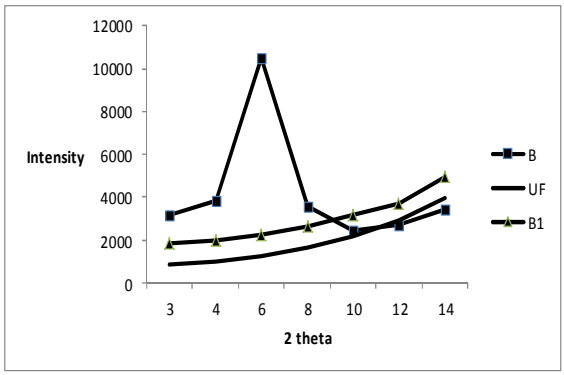
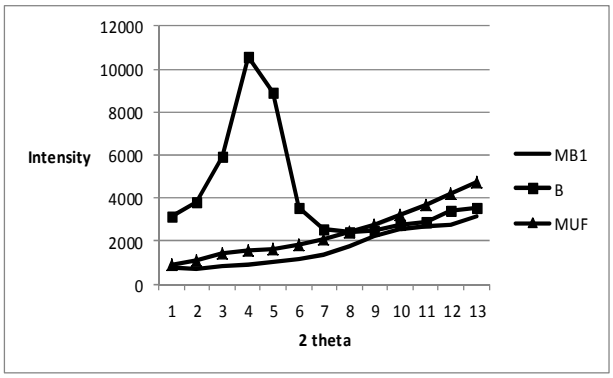


Figure II EDAX photograph of Nanomer PGV

Figure IIIa,b: XRD Spectra of Nanomer PGV (a) Nanomer PGV with UF resin, and (b) Nanomer PGV with MUF resin



(a)



(b)

periodic atomic structure of ordered zones of the nanoclay does not exist anymore. It states that nanoclay is completely exfoliated when mixed with UF resin or with MUF resin. The intensity peak of bentonite disappeared after being dispersed into the UF resin and MUF resin by mechanical mixing. This indicates that the UF resin or MUF resin was able to enter the interlayer space of nanomer PGV.

3.2 Test against White rot

To compare the efficacy of particle board made using Nanoclay incorporated UF resin and MUF resin, along with the control board and also boric acid incorporated particle board were manufactured. The efficacy of Nanoclay was evaluated against white rot fungus (*Polyporous Versicolour*) and the results are as tabulated in **Table III**.

The results indicated that OMMT had significant effects on the natural durability of the studied composite formulations[8]. Effects of addition of different percentages of nanoclay on the decay resistance and physicomechanical properties of natural fiber-reinforced plastic composites against white-rot fungi (*Trametes versicolor*) suggest that the lowest weight loss and the highest hardness were observed in the composite containing 5 phc nanoclay[9]**.** The results revealed that control boards had an average percentage weight loss of 15.15 and 10.13 in samples UF and MUF resin respectively. The lowest weight loss observed among the boards was of nanoclay (0.5 %) with a reduction of 49% from the control sample (**Table III**). The average weight loss observed for 0.25 % nanoclay incorporated UF resin was reduced by 38%. As the percentage of nanoclay increased to 0.5% in the UF resin, the average weight loss decreased was 7.86 with a reduction of 48 % from the control board was observed. The samples 0.25% & 0.5%, nanoclay reinforced MUF resin bonded particle board showed a reduction of 23% and followed the same trend as with UF resin. According to Hamid *et al* [10] an increase in the percentage of silica reduces the deterioration. As bentonite nanoclay contains silica which has reduced the average percent weight loss against white rot fungus. But there was no significant useful effect was found with boric acid (0.5%) particle board. Generally Boric acid is being used to treat the panel products in India. Hence in the present study Boric acid has been taken as a check to compare the efficacy of nanoclay against white rot fungus along with control board. But in the present study, Boric acid failed to control white rot in both resin system 15.39 and 10 .95 average weight loss was recorded in boric acid (0.5%) in UF and MUF resin particle board respectively. These results are at par with results of untreated control board.

Conclusion

From the study it can be concluded that unmodified Nanoclay Nanomer PGV was shown through XRD analysis to exfoliate into UF and MUF resin. The results indicates that 0.5% nanoclay in the UF resin has drastically reduced the average weight loss to about 50 % and to about 23% in the MUF resin. Nanomer PGV nanoclay can be used as preservative against White rot fungus. Nanomer PGV (0.5 %) has performed better than the chemical boric acid (0.5 %).But further study on its efficacy against termite, borer is needed.

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