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Biocel-WD a potent fungicide for Medium Density Fibre Board

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ABSTRACT

The present work deals with the evaluation of efficacy of Biocel-WD against wood destroying fungus. Biocel-WD (Sodium pentachlorophenate) was evaluated at 0.25 and 0.5% concentration on the weight of liquid resin taken for the experiment. The chemical was incorporated in the glue/adhesive composition. The fibres were blended with the glue. Control panel for Medium density fibre board (MDF) were also made without Biocel-WD incorporation in the glue. The treated and control samples were exposed against the wood destroying fungus for three months to test the efficacy of Biocel-WD. From the results of the study it was found that Biocel-WD at 0.5% resisted the attack of wood destroying fungus. The treated and untreated samples were also subjected for physical and mechanical properties as per relevant standard. The panels conformed to the physical and mechanical properties.

Introduction:

Wood is a major forest product which is being used widely for many purposes such as building construction, furniture, pulp and paper products etc. Shortage in the supply of durable wood species has resulted in the increased use of plantation grown timber species. Plantation timbers are non-durable in nature and hence easily get destroyed by various wood destroying agencies. In order to increase the service life of plantation timbers, preservative treatment becomes necessary (Tripathi et. al. 2009). The primary objective of the preservative treatment of wood is to increase the life of the material in service, thus decreasing the ultimate cost of the product and avoiding the need for frequent replacements. Moreover, in recent years, great changes have taken place in the Indian panel industry. The growing demand for raw material in wood panel industry have led to research into alternative panel products like Medium Density Fibre (MDF), Particle board (PB), etc.

Production of MDF products has increased dramatically and new plants are planned in India. MDF is used extensively in factory-assembled and ready-to-assemble furniture, as well as cabinets, underlayment, drawer fronts, moulding and counter tops. MDF is also replacing thin plywood and wet-process hardboard in the production of moulded and flush door-skins (Krzysik et al., 1999). It is generally accepted that wood-based boards show a greater resistance to decay than solid wood, although these products are still susceptible to biological attack (Curling and Murphy, 1999). Chung et al. (1999) showed that wood-based composite boards were as susceptible to microorganisms as solid wood.

It has been well established that wood rotting fungi particularly basidiomycetes damage forest wood even more than insects. These basidiomycetes are categorised as either white rot fungi (WRF) or brown rot fungi (BRF) (Rauel and Barnoud, 1985). Among these two, WRF degrade all major components of wood i.e. cellulose, hemicellulose and lignin by secretion of cellulolytic and lignolytic enzymes. The fungi that grow on wood and decay it are called as lignicolous fungi. Many species of primitive plants, known as fungi, live in wood. Some of these organisms use only the food that is stored in the wood (molds and sap stains), while others (wood-destroying fungi) attack the cellulose or lignin and ultimately rot the wood.

Compounds of pentachlorophenol (C_8Cl_5OH) and particularly the sodium salt have been widely used for a variety of agricultural and industrial purposes as a wood preservative. The major commercial application of technical grade preparations of pentachlorophenate is in wood preservative formulations, where it's fungicidal

and bactericidal actions inhibit the growth of wood-destroying organisms. It is also used as a fungicide, bactericide and algaecide in construction materials, emulsion polymers, paints, textiles, and finished paper products. Though the sodium salt of pentachlorophenate (Na-PCP) is a proven fungicide, it has been recognized as an irritating substance to the skin, eyes and the mucous membrane of nose, mouth and pharynx. The said problems are not associated with Biocel WD because of its granular nature as claimed by the manufacturer (M/s Excel Industries Pvt. Ltd. India). In an accelerated laboratory evaluation, rubber wood treated with borax and/or in combination with NaPCP (0.5 %) provided protection against white rot fungi (*Ganoderma applanatum* arid *Lenzites palisotii*) (*Balasundaran* and *Gnanaharan* 1990).

In India the most common method of treating wood based panel products with chemicals is Glue line poisoning (GLP) to enhance its service life. GLP process is a simple, economical and less cumbersome process of treating wood based panel to make it resistant against insect and fungus attack. In this process a small quantity (from 0.5 to 2.5%) of toxic chemicals are incorporated in the glue mix at the time of application of glue. This method does not require additional equipment. The GLP treated plywood neither gets discoloured nor unpleasant to handle. Moreover, glue line is relatively safe location for toxic chemical.

Wood preservative chemicals often interfere with the bonding quality. The interaction of wood preservative chemicals with the resin is detrimental to bond performance and ultimately reduces physical properties of the panel. Moreover, water repellency and dimensional stability cannot be overlooked. Wood preservative chemical must provide adequate protection against wood destroying organisms without sacrificing the physico-mechanical properties of the treated panel products. Hence, while assessing the bioefficacy of biocel WD, the effect of this chemical on some physico-mechanical properties were also studied.

Materials and Methods:

The present research was carried at the Biology laboratory of Indian Plywood Industries Research and Training Institute, Bangalore.

Resin system

Urea formaldehyde (UF) resin was used in the study to manufacture MDF.

Manufacture of MDF

Glue blending

The Eucalyptus fibers were dried to a moisture content of 4-6 % and added through the feeder of a specially designed rotary drum blender. UF resin (50% solids) was admixed with Biocel-WD at 0.25 and 0.5% concentration on the weight of liquid resin. In addition, 1 % of wax emulsion and 0.5% hardener on the weight of liquid resin was taken. The ingredients were mixed for about half an hour to achieve uniformity and then taken in spraying equipment for blending the fibres. The motor speed was maintained initially at 80 rpm and finally 100-120 rpm (for 2 minutes) for uniform blending of the resin with the fibres.

Fiber mat forming and pre pressing:

The glue blended fibers were placed into a mat forming box with base dimensions of 330mm x 330mm. Aluminium/ SS plates spreaded with releasing agents were placed on either sides of the fiber mat furnish. Prepressing and compression of the fibers were done by pressing a matching wooden plate on the fiber mat in the forming box by applying manual pressure. Supporting rods to control the thickness to 12mm were placed on either ends of the assembly.

Hot Pressing:

The assembly was then loaded into a hot press of size 350mm x 350mm wherein temperature of the platens was maintained at 155 - 160°C. Pressure of 25 kgs/sq cm for compression cycle and 12 kgs/sq cm for curing cycle with requisite curing time for respective resin systems were employed.

Initially the pressure is given higher so as to create a high surface density of the fiber board. The core density was then formed by reducing the applied pressure to 12 -16 kgs/sq cm. After stipulated period the pressure was brought down to zero for few seconds to release the generated steam and gases from the fiber boards. Then the press was completely opened to download the boards. The boards were kept for stabilization for about 24 -48 hours to attain equilibrium moisture content and then trimmed.

Physico-Mechanical test:

The trimmed boards were further dimensioned to required sizes and subjected for testing as per IS:12406 (Anonymous 2003).The results are given in Table 1.

Efficacy evaluation:

1) 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 1200C for 20 minutes was taken in Kolle flask. The test blocks were made of the size 50 mm x 25 mm x 15 mm. The treated MDF along with untreated control samples in six replicates were studied against white rot fungus (*Polyporous versicolor*). The whole set of flasks were kept at room temperature (25±5oC) and 60-70% relative humidity for 12 weeks. The test was carried out as per IS: 4873 (Anonymous, 2008). After the completion of 12 weeks, the samples were removed from the kolle flask autoclaved and the mycelium adhering to it was cleaned by taking care not to remove the splinters of the samples. The blocks were dried in an oven to a constant weight. The mean percentage weight loss was determined using following equation:

% weight loss = [(Wo-W1)/Wo] x 100

Where Wo is oven dry weight of sample prior to exposure and W1 is the oven dry weight of samples after exposure to fungus.

2) Mould fungi:

The toxicity test was carried out according to Padmanabhan et al. (1997). Treated MDF and untreated samples were utilized to study the bioefficacy against mould fungi. The specimen of size 12.5cm x 12.5cm was prepared. The moisture content of the sample was brought to 30% by dipping the samples in water for mould fungi study. All these samples in the lot of six replicates were exposed against mould fungi. The control samples were dipped in water. The water (control) and chemical treated samples were sprayed with a suspension of different moulds viz. *Aspergillus* spp. *Penicillium* spp and *Verticillium* spp. These samples were kept in incubation chamber (to maintain relative humidity of 70± 5% and temperature of 25± 5°C) for a period of 6 weeks. After 6 weeks of incubation, test samples were removed and the percentage of deterioration was observed and recorded.

Results and Discussion:

The present research work was undertaken to evaluate the bioefficacy of Biocel-WD against wood destroying fungus.

The average actual density of MDF board was 830 and 824 kg/m3 in case of Biocel-WD @ 0.25 and 0.5% concentration respectively (Table 1). The targeted density was 900 kg/m3. The prescribed average moisture content is 5-10% at ± 3% variation from mean moisture content as per IS :12406 (Anonymous 2003). The average moisture content calculated for the MDF samples treated with Biocel-WD at 0.25 and 0.5% concentration was 5.70 and 5.76% respectively. Whereas, the control samples recorded the moisture content of 5.53%. The treated samples have recorded a bit increase in moisture content as compare to control. This may be due to the wood preservative chemical i.e. Biocel-WD incorporation in the sample.

As wood is hygroscopic in nature, it absorbs moisture from its surrounding. The effect of moisture absorption by MDF is swelling in the thickness. The addition of Biocel-WD has less effect on the water absorption and swelling. The water absorption by MDF treated with Biocel-WD at 0.25% concentration was 8.95 and 17.75% after 2 and 24 hours of soaking respectively. While, the water absorption at 0.5% was 9.00 and 19.09% after 2 and 24 hours of soaking respectively. Though the water absorption for the treated samples were higher than the untreated, but felled within the prescribed limit as per IS: 12406 (Anonymous 2003). The thickness swelling was 6.12 and 6.1 at 0.25 and 0.5% concentration respectively due to general absorption after 24 hours. The average Modulus of Elasticity (MoE) was 3841 and 3794 N/mm2 for 0.25 and 0.5% concentration and are slightly lesser than the values of control boards (3953 N/mm2). The average Modulus of Rupture (MoR) for the Biocel-WD (@ 0.5%) treated samples was 40.00 N/mm2 against untreated control (43.21 N/mm2). Tensile strength perpendicular to surface (Internal bond strength) was 0.978 and 0.995 N/mm2 for 0.25 and 0.5% concentration respectively. Screw withdrawal strength was 3390 N for Biocel-WD treated samples at 0.5% concentration. From the physic-mechanical studies it can be seen that Biocel-WD treated samples conformed to the tested phsico-mechanical properties as per IS: 12406 (Anonymous 2003).

The treated and untreated samples were exposed against white rot in the kolle flask. The test was performed as per IS: 4873 (Anonymous 2008). The samples were kept in kolle flask for three months. After the completion of three months the samples were removed and the percentage of weight loss was calculated. The percentage of weight loss of 3.14% in the MDF samples treated with Biocel-WD at 0.25% concentration was found. The MDF samples treated with Biocel-WD at 0.5% concentration recorded 1.17% average percent weight loss against 100% weight loss in control samples (Table 2). The average weight loss in Biocel-WD at 0.25% was three times more than 0.5% concentration treated samples. These results clearly show that the new formulation prepared by M/s Excel India Pvt. Ltd. has proved excellent protection to MDF samples against White rot fungus.

Results for the exposure study of Biocel –WD treated samples against mould are presented in Table 3. The Biocel treated and untreated samples were exposed against mould fungi. After completion of exposure study, the samples were removed from the incubation chamber and observed for the surface area covered by the mould fungi. Biocel-WD proved to best mouldicide at both the tested concentration. The treated MDF samples were free from the attack of mould fungi. The untreated control samples were completely covered with the mould growth. The excellent efficacy of Biocell-WD obtained in the present study against the wood destroying fungus are consistent with the findings of Padmanabhan et.al. (1991).

Conclusions:

Biocel-WD was tested for its efficacy against wood destroying fungus. The method adopted to test the efficacy was as per IS: 4873 (Anonymous, 2008) for white rot fungi. The MDF was treated by addition of the preservative chemical in the glue. The treated and untreated control samples of MDF were exposed to wood destroying fungus for a period of three months. From the experimental findings the following conclusion can be drawn:

1. Biocel-WD at 0.5% on the weight of liquid resin has completely protected the MDF against wood degrading fungus.
2. Biocel-WD has not hampered the glue adhesion strength of the boards.

3. The new formulation developed by M/s. Excel Industries Ltd., Mumbai, is not irritant to the mucous membrane because of its granular nature as claimed by sponsor. Hence, Biocel-WD is not noxious as compared to the powder formulation of sodium pentachlorophenate.

Table 1 Physico-Mechanical properties of MDF as per IS:12406-2003

Tests	Prescribed Value	Results		
	Grade II	Control	Biocel-WD 0.25%	Biocel-WD 0.5%
Density.				
i) Average, Kg/m^3	500-900	848	830	824
ii) Variation from mean density,%	± 10	± 5.47	± 5.29	± 5.29
Moisture content, %				
i) Average	5-10	5.53	5.70	5.76
ii) Variation from mean moisture content	± 3	± 0.6	± 0.4	± 0.4
Water absorption, %				
i) After 2hr of soaking	9	7.1	8.95	9.00
ii) After 24hr of soaking	30	10.5	17.75	19.09
SWELLING, %				
a) Due to general absorption after 24hr soaking				
i) Thickness	7	4.23	6.12	6.1
ii) Length	0.4	0.223	0.32	0.34
iii) Width	0.4	0.255	0.35	0.38
Modulus of Elasticity, N/mm^2 (upto 20mm thickness)				
i) Average	2800	3953	3841	3794
ii) Minimum individual	2500	3860	3432	3202
Modulus of rupture, N/mm^2 (upto 20mm thickness)				
i) Average	28	43.21	34.77	40.00
ii) Minimum individual	25	42.69	31.31	41.11
Tensile strength perpendicular to surface (Internal Bond Strength), N/mm^2				
a) Dry test				
i) Average	0.8	1.148	0.978	0.995
ii) Minimum individual	0.7	0.75	0.72	0.723
Screw withdrawal strength, N				
a. Face	1500	2130	3400	3390
b. Edge	750	1130	1000	980

Table: 2. Efficacy of Biocel-WD against White rot

Chemical Concentration (%)	Mean percent weight loss *
0.25	3.14 (0.048)
0.5	1.17 (0.056)
Control	100 (0)

* Mean of six samples,
*values in parenthesis are standard deviation.

Table: 3. Efficacy of Biocel-WD against Mould Fungi

Chemical Concentration (%)	Mean percent surface attack *
0.25	00
0.5	00
Control	100

* Mean of six samples

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