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Effect of CSI Preservative on the Glue Shear Strength of Plywood Made Using Rubber Wood

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Abstract

BACKGROUND & OBJECTIVE: The purpose of the present study was to examine the effect of chitin synthesis inhibitor (CSI) on glue shear strength of plywood made from rubber wood veneer. **METHODOLOGY**: Plywood samples were prepared using Phenol Formaldehyde (PF) resin mixed with lufenuron and diflubenzuron at 0.5, 1 & 2% concentration. Plywood made with this glue was tested for glue shear strength in dry, wet and mycological state as per Indian Standard. **RESULTS**: From the results it was found that samples conformed the prescribed values of glue shear strength as per requisite standard. The study was limited to lab scale for testing the effect of CSI on the shear strength.

Keywords: CSI, Lufenuron, Diflubenzuron, Wood Preservative, Mechanical Properties

1. Introduction

Panel products require some type of preservative treatment in order to perform satisfactorily under more severe conditions. As wood-based panel products are more widely used, it is inevitable that some will found environments conducive to decay and insect attack. A new approach to insect pest control is the use of substances that adversely affect insect growth and development. These substances are classified as “insect hormone mimics” or “insect growth regulators” (IGRs) owing to their effects on certain physiological regulatory processes essential to the normal development of insects or their progeny. Chitin Synthesis Inhibitors (CSI) are chemicals that are toxic only to insects and other arthropods. It is being considered as "Third generation insecticides" having an effective stomach and contact mode of action. CSIs, primarily the benzoylphenylureas (BPUs) have been considered to be “soft insecticides” belonging to the group of biorational control agents. Lufenuron and diflubenzuron belong to halogenated BPUs which constitute a class of the IGRs that interfere with insect growth and development by inhibiting chitin synthesis at the time of moulting. It is effective in controlling immature stages of insects. Both the chemicals are relatively a new member of the acylurea class of CSI and are highly effective against the embryonic and larval stage of insect pest [1, 2].

In India, the most common method to treat the plywood with preservative chemicals against wood destroying insects is Glue line poisoning (GLP) to enhance its service life. GLP process is a simple, economical and less cumbersome process of treating plywood to make it resistant against insect 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 to the veneers. The toxic ingredient gets diffused into the veneers from the glue line during hot pressing making the plywood resistant to insect attack. 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. However, the preservative may interfere with gluing processes and associated bond-strength development during the hot-pressing stage of manufacture. Glue line quality is one of the most important properties of plywood, influencing almost all its physical and mechanical characteristics.

Despite the reported problems of gluing treated timber, some studies report on successful experiments using similar procedures to that of gluing untreated woods. Lee *et al.*[3] assessed the shear strength of Korean pine (*Pinus koraiensis*) and Japanese larch (*Larix leptolepis*) treated with CCA, Copper -azole and CB-HDO (a preservative containing Bis-(N cyclohexyldiazeniumdioxy)-Copper (Cu-HDO), Copper hydroxide carbonate and Boric acid), glued with Melamine urea formaldehyde (MUF), Melamine formaldehyde (MF), Phenol formaldehyde (PF) and Resorcinol formaldehyde (RF) adhesives. Gluing was done at room temperature for 24 h

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applying a clamping pressure of 0.79 N/mm^2. Although gluing quality was not evaluated by delamination test, satisfactory shear strength was obtained as per Anonymous[4].

Miyazaki and Nakano[5] also reported satisfactory shear and delamination strengths evaluated on the basis of the Japanese Agricultural Standard when studying the effects of three commercial preservatives such as AAC, ACQ, and CA on commercial adhesive properties such as Phenol resorcinol formaldehyde (PRF), Resorcinol formaldehyde (RF) and aqueous vinylpolymer solution isocyanate. Literature survey reveals that the effect of CSI based wood preservatives on the glue shear strength has not been documented. Hence, a study was taken up to assess the effect of preservative chemical on the glue shear strength of the plywood.

2 Materials and Methods

2.1 Glue line treatment of plywood

Three concentration levels viz., 0.5, 1 & 2% of lufenuron and diflubenzuron respectively on the weight of liquid resin were mixed with PF resin as glue additive. Control samples were also prepared in which insecticide was not added in glue. Laboratory scale plywood was prepared by using rubber wood veneers for three ply construction. The veneers were coated with glue mixed with the preservative chemical. After the requisite pre-assembly time, glue-coated veneers were hot pressed at 140±5^{o}C with a pressure of 14Kg/m^2 and pressing time of 6-7 minutes for 4 mm thick plywood.

2.2 Pot life

Effect of addition of the chemical (lufenuron and diflubenzuron) on pot life of the adhesive was assessed through measurement of flow–time after eight hours of mixing the preservative chemical in the resin. Eight hours period was taken with the assumption that resin should remain usable for the entire duration of a normal production in plywood manufacturing industry.

2.3 Adhesion of plies test

Adhesion of plies (knife test) was carried out to determine the effect of chemical on glue shear strength in Dry (ambient temperature 27±2^{0}C & relative humidity 65±5%), wet (after 72 hours of boiling) and mycological (after 21 days in simulated condition) state. The test was performed as per IS: 1734-Part 5, 6 and 7[6] respectively and results were compared with prescribed values of glue shear strength given in IS 710[7].

2.5 Statistical analysis

The results of glue shear strength were analysed by one-way analysis of variance to compare the effect of chemical treatment on glue shear strength at P=0.05 (TableI to Table VI).

3. Results and Discussion

Studies on pot life of PF resin after the addition of lufenuron and diflubenzuron from 0.5 to 2% based on the weight of liquid PF resin (48% solid content) indicated that addition of chemical has not changed the viscosity after 8 hours. The flow rate recorded after mixing the chemical in the glue was 26 seconds. The incorporation of lufenuron and diflubenzuron in glue line indicated no adverse effect on the pot life of PF resin.

Results of the glue adhesion test are given in Fig. I-VI which shows that addition of preservative chemical to PF resin does not have significant adverse effect. Bond strength of plywood made by using PF resin mixed with lufenuron and diflubenzuron in the entire range of doses i.e., from 0.5 to 2% were tested for glue shear strength in dry, wet and mycological

Table I : ANOVA for GSS (dry) Lufenuron

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	3977	3	1325.667	3.519625	0.033883	3.098391
Within Groups	7533	20	376.65			
Total	11510	23				

Table II : ANOVA for GSS (wet) Lufenuron

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	7107.667	3	2369.222	4.076315	0.020655	3.098391
Within Groups	11624.33	20	581.2167			
Total	18732	23				

Table III : ANOVA for mycological Lufenuron

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	8273.188	3	2757.729	13.00943	0.000443	3.490295
Within Groups	2543.75	12	211.9792			
Total	10816.94	15				

Table IV : ANOVA for GSS (dry) diflubenzuron

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	3991.125	3	1330.375	11.16633	0.00016	3.098391
Within Groups	2382.833	20	119.1417			
Total	6373.958	23				

Table V : ANOVA for GSS (wet) diflubenzuron

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	7443.458	3	2481.153	5.155374	0.008391	3.098391
Within Groups	9625.5	20	481.275			
Total	17068.96	23				

Table VI : ANOVA for mycological diflubenzuron

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	5462.25	3	1820.75	10.92723	0.000953	3.490295
Within Groups	1999.5	12	166.625			
Total	7461.75	15				

conditions. Twelve samples of 3 different concentrations viz., 0.5, 1 & 2% and control samples for the comparison were taken for testing.

The average glue shear strength of dry samples in case of lufenuron at 0.5% was 1562 N (Fig I). 1520 N of average glue shear strength was found in lufenuron at 1 %. The highest tested concentration of lufenuron in this study was 2%. The samples tested with lufenuron (2%) recorded the average glue shear strength of 1390 N. Similarly, in case of glue shear strength of wet samples, the lowest tested concentration i.e. 0.5% recorded the average glue shear strength of 1160 N (Fig II). As expected the highest tested concentration of lufenuron i.e. 2% recorded 1036 N of average glue shear strength. Whereas, the untreated control samples recorded the highest value of 1480 N. Same trend was found in case of mycological test (fig. III). The treated samples recorded less value as compared to the untreated samples.

1548, 1508 and 1393 N average glue shear strength of dry samples found in diflubenzuron at 0.5, 1 and 2 % concentration treated samples respectively. Diflubenzuron at 2% recorded to the lowest glue shear strength but was within the prescribed limit. The glue shear strength of wet samples is given in fig. V. From fig. V it can be seen that the 1173 N of average glue shear strength was found in diflubenzuron 0.5%. The low value of glue shear strength was found in samples treated with diflubenzuron at 2%. Similar trend was also found in the case of glue strength of mycological samples (Fig. VI). The lowest value of 1027N was found at diflubenzuron 2% and the highest was found in the untreated control samples (1640 N). 1420 N was recorded in diflubenzuron at 0.5%.

The strong dose dependent results have been found in this experiment. As the dose increases the shear strength also decreases however, the values are within the prescribed limit as per the relevant specification. The highest tested concentration of both the chemicals also recorded the glue shear strength within the prescribed limit. The statistical analysis of the results showed that the chemical had little effect on the shear properties of the plywood. Wood preservative chemical treatment is mandatory in some special grade plywood in India. Preservative chemicals are being used to treat the panel products to make it resistant against wood destroying organisms. Addition of preservative chemical should not negatively affect the glue shear strength of the plywood. Hence, the present study was taken up to study the effect of two CSI chemical on the glue shear strength of plywood.

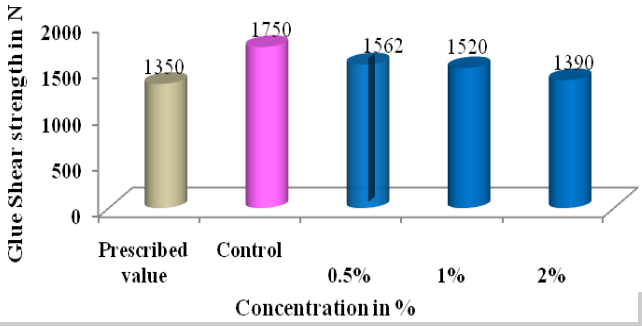

Fig I: Effect of Lufenron on Glue Shear strength of Dry Sample

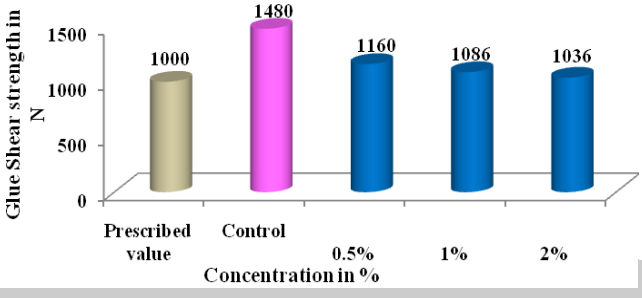

Fig II: Effect of Lufenron on Glue Shear strength of Wet Sample

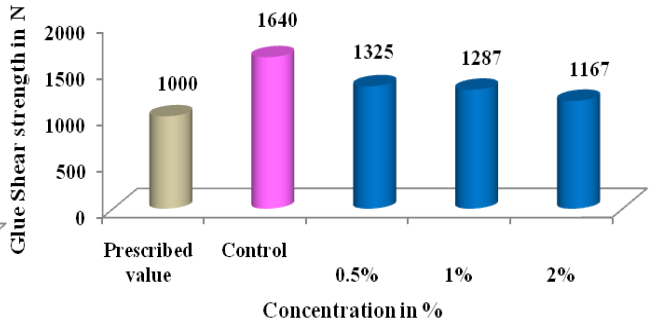

Fig III: Effect of Lufenron on Glue Shear strength of Mycological Sample

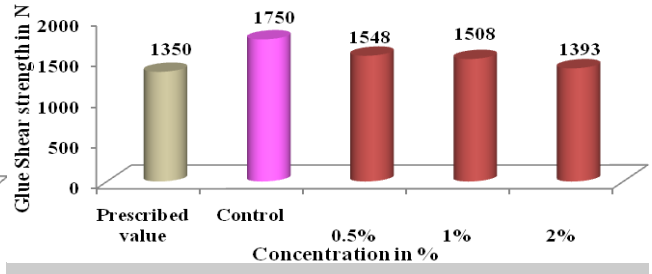

Fig VI: Effect of Diflubenzuron on Glue Shear strength of Dry Sample

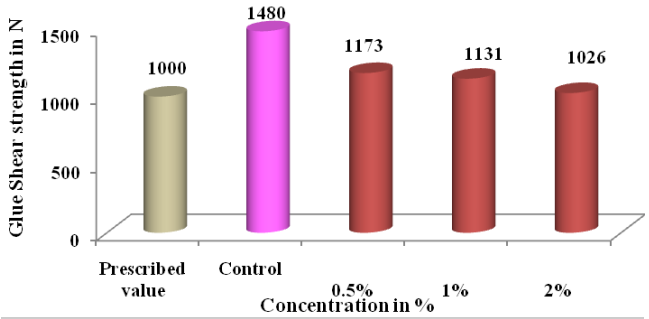

Fig V: Effect of Diflubenzuron on Glue Shear strength of Wet Sample

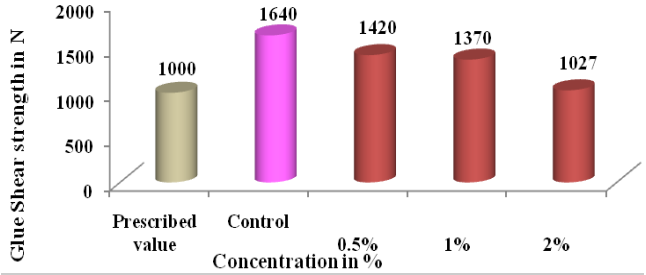

Fig VI: Effect of Diflubenzuron on Glue Shear strength of Mycological Sample

4. Conclusions

From the results of the study it can be concluded that lufenuron and diflubenzuron are suitable for treating plywood to make it resistant against wood destroying insects without sacrificing the glue shear strength of plywood. Results showed that glue shear strength decreases with increase in concentration of the preservative chemical. However all the samples tested (from 0.5 to 2% concentration) were found conforming to the prescribed values of glue shear strength as per IS:710-2010[7].

Conflict of interest

The author's declares none.

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