Evaluation of New Boron Fixation System for Wood Preservation

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Abstract— **In order to address increased public concern about demand for the eco-friendly preservatives an environment friendly wood preservative, system need to be developed that go beyond the scope of traditional wood preservation. In this study combination of Glycerol/Glyoxal has been used as a fixing agent to fix boron. From the leaching studies it has been observed that boron treated wood samples indicates 0.59% compare to that of control samples which indicated 2.87%. From the results it has been observed that Glycerol/Glyoxal acts as fixing chemical and reduces the boron from the treated wood samples.**

Boron/Glycerol/Glyoxal of 8% concentration preservative chemical treated wood samples have conformed to the exposure limits of 36 months without attack from the termite when tested as per Indian Standard - 4873. Hence from the study it is recommend that 8% of Boron/Glycerol/Glyoxal concentration can be used for preservation of wood as a fixing agent to control leaching from the treated wood samples.

I. INTRODUCTION

Borates such as boric acid, borax or disodium octaboratetetrahydrate (DOT) have proved their efficiency for many years as wide spectrum wood preservatives. They have many advantages including being inexpensive, odourless, colourless and non flammable. They are also soluble in water allowing them to be introduced in wood by conventional methods like dipping-diffusion or vacuum-pressure treatments. On the other hand, this high water solubility makes boron compounds easily leachable from treated wood and thus boron treated wood is not suitable for outdoor application (Lloyd 1998, Peylo and Willeitner 1997).

Boron compounds have been shown to have a lower human toxicity (Teshima *et al.* 2001, Usuda *et al.* 1998, Jansen *et al.* 1984) than for some animals' species (Hamilton and Buhl 1990, Maier and Knight 1991), and boric acid has been considered environmentally acceptable for many years. The key issue to expand boron's use for wood protection appears to be their fixation into wood but allowing for sufficient mobility so they remain fungicidal (Obanda *et al.* 2008). Several different methods have been tried to decrease borate leachability from wood, including forming complexes of boron with flavonoid tannins (Pizzi and Baecker 1996). Another system involved a 2 step impregnation of copper, zinc and boron with tannins, with this system having good efficacy against wood destroying fungi (Scalbert*et al.* 1998).

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Water borne solutions of boric acid, gelatin and tannins can also be used to treat wood (Thevenon 1999).

However under exterior conditions biological resistance of treated wood decreases rapidly due to the high leachability of boron. An alternative to this drawback concerns the use of water repellent or polymer systems which reduce leaching in treated timber (Murphy et al 1995). In order to address increased public concerns about demand for the environment friendly wood preservative system need to be developed that go beyond the scope of traditional wood preservation. In addition to being effective against fungus, termites and borers wood preservative chemical must be nonvolatile environmentally acceptable safe to handle and possess low leachbility.

More recently new wood preservatives based on protein borates have been described to greatly retard the leaching of boron from treated timber (Thevenor et. al 1997 1998). In a similar manner we describe here the development of a new low cost boron preservation system for hazard class III involving glycerol/glyoxal and H_3BO_3 mixtures capable of improving not only the durability but also the dimensional stability of timber treated with them.

II. LITERATURE SURVEY

Boric acid and sodium borate have been used as wood preservatives since the 1930s (Murphy 1990) and are valued for their protective capacity against decay fungi, wood boring insects and at slightly higher retention levels of termites. Boron is also a relatively cost effective chemical and more important has minimal toxicity against non-target organisms (Greaves 1990). In addition, boron-based preservatives are colourless, odourless, noncorrosive, and non-flammable (Hashim et al. 1994;Manning and Artur 1995

One option for decreasing the leachability of boron wood preservatives is to use mixtures of sodium borate or boric acid and polyethylene glycol (PEG). Polyethylene glycol can almost completely re-place water and dimensionally stabilize non seasoned wood (Goldstein and Laos 1973).

Extensive research has been conducted with varying anhydrides and monomers (Imamura and Nishimoto, 1986; Johnson and Rowell, 1988; Beckers et al., 1994; Takashi, 1996; Forster et al., 1997; Suttie et al., 1997; Timar et al., 1999; Devi et al., 2003), methyl methacrylate (MMA), Allyl Glycidyl Ether (AGE), textile finishing agents such as DMDHEU and several different water repellents such as organosilicon compounds, oils, etc., to limit biocide release from treated wood and increase decay and termite resistance of biocide-treated and chemically modified wood (Verma et al., 2005; Xie et al., 2005, 2008). According to Peylo and Willeitner (1995), the role of boron as a wood preservative is discussed, it is referred the fact that, in traditional treatment methods as those pointed out above, boron is not fixed chemically to wood, and it will be leached out if wood in service is subjected to an wet environment. That is why research is active to find methods to fix boron in wood. On the other hand, wood should perform well in dry conditions or when protected against moisture by finishes.

Treatment of wood with vinyl polymers is advantageous for both preservation and water repellence. Treatment of wood by the polymerization of various monomer and monomer systems contributes to dimensional stability and strength properties of wood (Yalinkilic et al., 1998; Solpan and 1834 Afr. J. Biotechnol. Guven, 1999 a, b, c).Gezer *et al.* (1999) succeeded in imparting resistance to boron leaching by a sequential treatment with sodium 188 Caldeira, F. borate and then with polyethylene glycol (PEG).Experimental data on the diffusion of boron salt solutions (boric acid (H_3BO_3)/borax) in heartwood specimens of *Eucalyptus globulus* Labil, resulted in that the effective diffusion coefficients were in the order of 2.6 x 10-11 m^2/s, and the effect of wood anisotropy was found negligible.

Wood preservatives based on protein borates, obtained by just mixed water solutions of protein and boric acid, as well as in the case of premanufactured protein borate salts, were shown to greatly retard the leaching of boron from treated timber (Thevenon *et al*., 1997). Pizzi and Baecker (1996) presented a boron fixation mechanism based on a reaction in which boric acid induces auto condensation of flavonoid tannins. The boric acid is partly fixed to the network by the auto condensed tannin in the wood but conserves sufficient mobility to maintain its preservative action. A combination of a silicic acid monomer aqueous solution with boric acid proved to be another method for boron fixation in wood, as there was little leaching of agent in leaching tests (Yamaguchi, 2002). Field tests during three rainy seasons (about 6 months in total) in three years demonstrated that the silicic acid:boric acid agent had high water resistance ability worthy of application in the outdoors (Yamaguchi, 2003).

Boron compounds offer some of the most effective and versatile wood preservative systems available today, combining the properties of broad spectrum efficacy and low acute mammalian toxicity (Freeman *et al*., 2003). However, more recently (August, 2008) the European Commission decided to make an ATP – Adaptation to Technical Progress of Council Directive 67/548/EEC (the 30^{th} ATP), and since then boric acid and disodium tetraborate decahydrate are classified as reprotoxic category 2. These boron chemicals are classified as substances toxic for reproduction category 2 for both fertility and developmental effects. The directive apply to them the risk phases R60 (may impair fertility) and R61 (may cause harm to the unborn child).

Boron is a low mammalians toxicity wide spectrum wood preservative recognized as both an effective insecticide and a fungicide which is widely used industrially for dip treatment for timber protection. In order to address increased public concerns about demand for the ecofriendly wood preservative system need to be developed that go beyond the scope of traditional wood preservation. In addition to being effective against fungus, termites and borers wood preservative chemical must be nonvolatile environmentally acceptable safe to handle and possess low leachbility. In the present study glycerol and glyoxal was used to fix the boron in treated wood

III. MATERIALS AND METHODS

Boron was diluted with water at three levels for evaluation against termites' viz. 4%, 6%and 8%. These concentrations were used to treat solid wood and veneers by dipping method.

Treatment of solid wood:To study the toxicity of the chemical against termites, the most non-durable timbers such as poplar wood (populus deltoids) was selected. The sample size of solid wood for termite test was 30 x 2.5 x 2.5 cm3. Solid wood samples of the sizes mentioned above were separately given 30 minutes to one hour dipping in the three above mentioned concentrations. The numbers of sample maintained were 36 for each concentration and exposed against termites.

Leaching Procedure:The treated solid wood samples were conditioned and subjected to leaching study. Before subjecting to leaching, samples calculated for retention of boron in the treated wood samples. Then the conditioned wooden planks were kept in beaker and kept under running water for 8 hours. After 8 hours samples were kept in distilled water for 36 hours. After 36 hours samples was removed and tested for boron analysis and results were recorded. The degree of fixation was calculated according to following equation:

$$FD = \frac{U-L}{U} X100(\%)$$

Where: FD is the degree of fixation (%) U is the average uptake of copper and potential amount of leachable copper (kg/m³) L is the leached out copper in oil related to the amount of wood (kg/m³).

IV. RESULTS AND DISCUSSIONS

Solid wood samples of size 1feet x 1inch x10mm thickness were also dipped in 4%, 6% and 8% preservative solution for period of 3 days duration. After dip treatment samples were taken out for tested chemical spot test and calculated the retention of chemical and tabulated as shown in the Table 1. The treated plywood and solid wood samples were exposed for termite and borer attack for period of 36 months along with control samples. Observations were made by monthly intervals and results were recorded. After 3 months exposure studies both treated and untreated control samples were taken out and calculate for percentage of mold growth on veneer samples as shown in the Table 3.After 3months exposure studies treated samples of 1%, 2%3 % showing mold growth on the surface of veneer samples, whereas 3%concentation showing less mold growth on veneer samples, which indicated that after leaching studies the boron chemical still persist on the surface of veneer samples and untreated control samples were showing full area of mold growth.

Evaluation of toxicity against Termites: The solid wood samples were treated with 4%, 6% and 8% were also tested against termites has indicated no attack in 8% concentration as shown Figure 1, whereas 4% and 6% was badly attacked along with control samples as shown in the Figure 2. From the results it is confirmed that only solid wood samples at 8% concentration was showing resistance to termite attack as shown in Table.2

Table: 1 Retention and leached boron content

Concentration	Retention of boron chemical(Kg/m^3)	Retention of boron after leaching 36 hours (Kg/m^3)	% of leached boron content
4%	0.406	0.355	0.51
6%	0.412	0.384	0.28
8%	0.538	0.479	0.59
Control	0.639	0.352	2.87

Table.2 Solid Samples Treated with Boron /Glycerol/GlyoxalPreservative Chemical Exposed for termite Attack.

Concentrations	6 months	12 months	18 months	24 months	30 months	36 months
4%	Not Attacked	Not attacked	Not ed Attack	Attacked	Attacked	Attacked
6%	Not Attacked	Not Attacked	Not Attacked	Attacked	Attacked	Attacked
8%	Not Attacked	Not Attacked	Not Attacked	Not Attacked	Not Attacked	Not Attacked
Control	No Attack	Attacked	Attacked	Attacked	Attacked	Attacked

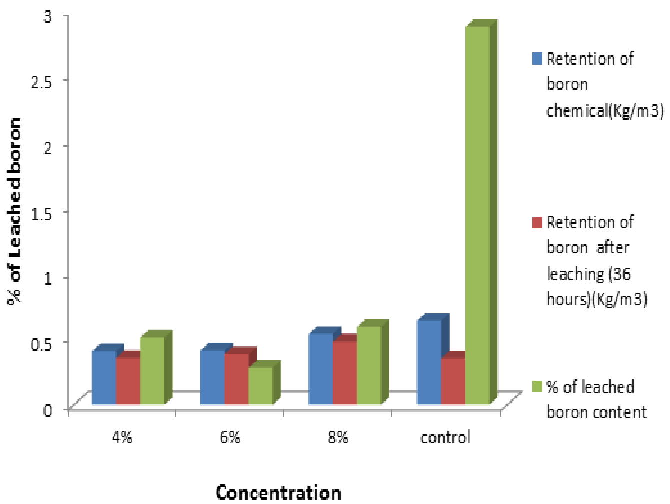

Fig.1Treated

Fig.2 control samples

CONCLUSION

From the results, samples treated with boron and glycerol/glyoxal have efficient fixation capacity in the wood. On the basis of results and discussion the solid wood samples treated with 8 % concentration was protected from termites whereas plywood samples treated with glue line treatment was attacked. From the above experimental studies leaching of boron from the treated wood samples were 0.59% compared to control samples having 2.87%. Hence it is recommended to use glycerol and glyoxal as fixative agent to treat boron preservative chemical for exterior conditions.

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