

International Journal of Scientific Research and Reviews

Effectiveness of Copper –Chrome - Boron as a Wood Preservative - A Short Review

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ABSTRACT:

Protecting wood from different environmental condition is considered to be a hurdle task. Though the chemical wood preservatives can achieve this goal, it may causes adverse impact to the ecosystem. In this context, the use of inorganic boron along with the combination of copper and chromium as Copper-Chrome-Boron (CCB) gains importance in the wood preservation industry. These review discuss the findings of studies conducted all over the world regarding the effects of CCB treatment on the inherent physical and mechanical properties of wood, resistance to bio deterioration in different environmental conditions and resistance to leaching.

KEY WORDS: Copper-Chrome-Boron, mechanical properties, bio deterioration, leaching.

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INTRODUCTION

Wood is considered to be an important structural material for terrestrial and aquatic applications. When it is used in outdoor applications without any treatments, it will prone to degradation by a wide range of natural causes¹. Wood can be protected from the attack of fungi, insects, marine borers and other deteriorating organisms by using chemical preservatives². The chemical wood preservatives generally classified into oil born and water born preservatives. Among these, water born fixed type of preservative is preferable for outdoor applications³. The water-born fixed type preservatives have a fixative salt, usually sodium or potassium dichromate. These fixatives reduce the leaching of toxic elements like arsenic, fluorides, copper, boron etc from the wood by fixing these elements into the wood. So the water boron preservatives are suitable for marine applications⁴.

Copper - chrome –arsenic (CCA) has been widely used in the treatment of wood for decades for indoor and outdoor applications and it is found very effective to protect wood against insects (termites and borers), decay fungi and marine borers. However, environmental concerns about the use of CCA have been raised due to the chance of dispersion of arsenic into the environment and possibility of contamination of soil and groundwater and its risk for humans⁵. The use of CCA has been restricted for outdoor applications in many countries because of the toxicity of arsenic present in the formulation⁶. In 1970s formulations were produced in which arsenic was replaced with less toxic components such as phosphate to give copper-chrome phosphate (CCP), boron (CCB) or fluoride (CCF). Of the three types, CCB is the most acceptable alternative on both environmental⁷ and efficacy grounds^{8,9}.

It has been reported that CCB may be as effective as CCA in sites where temperate climatic conditions with long dry periods are dominant¹⁰. The restriction of borates to indoor applications has been overcome by the use of more complex formulations where boron is just one active ingredient in a formulation containing two or more e.g., in CCB. Comparison of acute oral LD50 values for boric acid, sodium orthophosphate and arsenic pentoxide indicates that CCB and CCP would be expected to have lower toxicity than CCA, and presumably proportionately less potential for adverse environmental impact. The toxicological studies on mouse showed that boron (LD50 – 1740 mg/kg) in CCB is comparatively less toxic than Arsenic (LD 50-31mg/ kg) in CCA¹¹.

This review focuses to consolidate the important findings of researchers related to the effectiveness of CCB for indoor and outdoor applications including the marine application. This communication also focused on different views regarding the effect of CCB on the physical and mechanical properties of wood and the leachability of preservative from treated wood.

EFFECT ON THE PHYSICAL AND MECHANICAL PROPERTIES OF WOOD

The chemical wood preservation is extremely important to protect wooden materials from bio-deterioration. In some cases, it will affect the structural properties of wood⁵. The studies conducted by Felipe et al¹² on the effect of CCB treatment on the mechanical properties of Parica Wood (*Schizolobium amazonicum*). The study concluded that the impregnation of CCB in the wood did not change the properties like apparent density, shear strength, hardness, strength and stiffness in compression parallel to the grain. Simsek¹³ observed that there is a 4% and 6 % decrease in the compressive stress parallel to grain (CSPG) value of CCB (4%(w/v)) treated Scots pine (*Pinus sylvestris*) and Oriental beech (*Fagus orientalis*) wood panels. The modulus of rupture (MOR) value is also found decrease but which is better than borax and boric acid treated panels. Studies conducted by Rabbi et al¹⁴ found that the impregnation of CCB in mango wood panels by full cell process improves the physical properties of wood. Usta and Hale¹⁵ conducted a study on the effect of thermal treatment of CCB preservatives on the static bending properties of Turkish fir (*Abiesborn mulleriana*). They find out that modulus of elasticity (MOE) and MOR were reduced to a small extent by the full-cell vacuum pressure wood treatment by using 3% of CCB heated at 40 °C. Shanu et al¹⁶ carried out an experiment to analyse the effects of 8% CCB (chromate-copper-boron) preservative treatment on physical and mechanical properties of *Albizia richardiana* wood using dip treatment. The results showed that the Physical and mechanical properties of the wood improved by treating with CCB preservative.

The studies conducted on the oriental beech (*Fagus Orientalis*) and Calabrian pinewood (*Pinus brutia*) also revealed that the high concentration of boron compounds reduced the static bending properties mainly MOR value compared to the untreated panels¹⁷. Similar studies conducted with CCA on the mechanical properties of the wood revealed that there is no significant difference in the mechanical properties of treated and untreated samples¹⁸. Kolman¹⁹ states that the reduction occurs in the mechanical strength properties of CCB treated panels is mainly due to the hydrolysis of wood tissue by the activity of borates. Winandy²⁰ also states that the acidic nature of wood preservatives decrease the mechanical properties of wood due to the hydrolysis of wood components.

RESISTANCE TO BIO DETERIORATION ON TERRESTRIAL ENVIRONMENT

Several workers have studied the performance of CCB against decay compared with CCA preservatives. Wakeling²¹ reported that in New Zealand at some sites CCB preservatives (pine sapwood) showed good performance, similar to CCA against wood rot fungus, but the studies

revealed that CCB treated panels failed to resist the attack of copper-tolerant brown rot fungi. Similar results have been presented from a comparative study between CCB and CCA preservatives in Malaysia²². Hedley⁸ showed that CCB preservative formulations performed as well as CCA at sites where soft rot predominated or where no particular decay type was dominant. The susceptibility of CCB treated panels to copper tolerant brown rot fungi have also been reported by Gray and Dickinson²³; Tamblyn and Levy²⁴. Gray and Dickinson²³ concluded that CCB shows better performance than CCA against soft rot decay fungi because greater amounts of copper are absorbed during treatment. Humar et al.²⁵ carried out the experiments on Norway spruce (*Picea abies*) shown that 5% CCB solution reduced the mass loss of wood over eight weeks of exposure studies under copper tolerant fungi like *Gloeophyllum trabeum*, *Leucogyrophana pinastri* and *Antrodia vaillantii*.

The studies conducted by Selamat et al²² proved the effectiveness of CCB treatments (5,6 and 8% (m/v)) to increase the durability of non-durable Malaysian timbers like *Koompassia malaccensis* and *shorea robesta* against the attack of termites and other decaying organisms during a year of graveyard test. In the temperate conditions, the service life of CCB treated wooden fence posts is found better even after 18 years of exposure¹⁰. The Denison single blow impact bending test of these panels shows there was no significant reduction of toughness in any of the zones of these poles.

The resistance of CCB against weathering has been reported since 1974 by sell et al²⁶. The anti-weathering properties of CCB treated wood is mainly attributed to the protective effect of Cr-Cu-salt solutions on the wood surface. Yalinkilic et al²⁷ studied outdoor performances of polyurethane varnish and alkyd-based synthetic varnish coated over chromium-copper-boron (CCB) impregnated Scots pine and chestnut. They reported that CCB pre-impregnation resists weathering of wood. Gerenji et al²⁸ studied the impact of CCB wood preservative on the corrosion of ST37 steel by using dynamic electrochemical impedance spectroscopy (DEIS), potentiodynamic polarization, and scanning electron microscopy. Results of corrosion tests revealed that CCB displayed inhibitor properties, behaving predominantly as a slightly anodic inhibitor.

RESISTANCE TO BIO DETERIORATION ON AQUATIC ENVIRONMENT

The CCB treated wood panels exposed in the Black Sea, Mediterranean sea and Marmara sea shown to be good condition over a year of exposure, while the untreated panels exposed in all test sites excepts Marmara heavily destroyed by marine borers²⁹. The exposure studies carried out in 6 stations around Turkey using 10 % CCB treated panels of around 18 European and 15 African wood species over a year shows the treated panels were remains unattached with borers³⁰.

Rao and Balaji³¹ reported that CCB treated structures showed an excellent resistance against bio-deterioration and the service life is 7 to 8 times compared to controls in marine conditions.

Marine exposure trials were conducted on *Albizia lebbek* and *Tetrameles nudiflora* timbers after pressure impregnation with two common wood preservatives viz. CCA(5%) and CCB (5%) shows both the preservatives increase the service life of the wood compared to control panels³². Tarakanadha³³ carried out a study to find out the impact of wood preservatives on the settlement and growth of marine fouling organisms in *Bombax ceiba* at Krishnapatnam coast. The panels were pressure treated with copper chrome arsenic (CCA), copper chrome boric acid (CCB), ammoniacal copper zinc arsenate (ACZA), ammoniacal copper quaternary (ACQ). The results showed that a greater variety of fouling assemblages were on control, CCB and CCA treated panels compared to ACZA, CC and ACQ treated panels. CCA treated panels had heavier settlement of barnacles followed by oysters and bryozoans, while CCB treated panels had heavier settlement of oysters followed by barnacles and bryozoans. This study also shown that all treated panels were resist to bio deterioration while the untreated panels were completely degraded after 6 months of exposure.

Muslich and Hadjib³⁴ reported that the suitable preservative treatment could increase the durability of low value timbers available in Thailand for marine applications. They compared the durability of CCB(3%) treated and plastic impregnated panels of plantation crop timbers (*Paraserianthes falcataria*, *Agathis sp*, *Pinus merkusii*, *Hevea brasiliensis*) with the conventionally used forest timbers (*Tectona grandis*, *Instia biyuga*, *Vitex pubescens*, and *Eusideroxylon zwageri*) as untreated control for marine applications. The exposure studies were carried out in the waters of Rambut Island. After 6 and 12 months of exposure, the results showed that CCB preserved timber were more durable than plastic impregnated timber and untreated timber. Wood samples were mostly attacked by marine borer organisms from the family of Pholadidae and Teredinidae. The experiment results revealed the possibility of using those plantation forest timber species for marine construction purposes. Another study conducted by Muslich³⁵ on the 16 wood species seen in Thailand also reported that the CCB (3%) treated panels resist the marine borer attack. Muslich and Rulliaty³⁶ conducted the similar study on 25 locally available wood species from Java. Most of the specimens treated with CCB were resistant to marine borers.

LEACHING OF BORON FROM THE CCB TREATED WOOD

The magnitude of boron leached from CCB treated wood is higher than that of copper and chromium^{37,38}. Previous studies show that while fixing boron may reduce leaching, it may lock the boron resulting in loss of biological efficacy³⁹. Ana and Jose⁴⁰ evaluated the leaching of copper, chromium and boron from 1.6% of CCB (Cu 9.7%; Cr, 15.9%; B, 0.36%) treated panels by using the laboratory assay and atmospheric exposure studies conducted based on the Spanish weathering conditions for one year. According to the results the total emissions of Cu and Cr obtained in a laboratory assay were lower than those for panels under field conditions. However, the percentage of

boron leached from wood was found to be higher in laboratory than in field assays. The initial rate of leaching of boron is found to be higher than other metals in both experiments.

CONCLUSION

Copper –Chrome-Boron is considered to be more eco-friendlier wood preservative than Copper-Chrome-Arsenic. It is found to be effective on both terrestrial and aquatic applications. This review article is focussed to consolidate the important studies conducted all over the world on the effectiveness of CCB treatment. In this review we have discussed different aspects of CCB preservative treatment includes its effectiveness to increase the durability of wood in different environmental conditions, effects on the inherent physical and mechanical properties of wood and the leach ability of metal components from the treated wood. This review is believed to be useful for the researchers, students and common people for getting a better understanding of this preservative.

ACKNOWLEDGEMENT

The authors gratefully acknowledge the support from the Coconut Development Board (CDB) for funding this study. They also thank, Director CIFT for the facilities provided and for his kind encouragement and guidance during the course of the study.

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