# MARKET OPPURTUNITIES FOR BORATE TREATED LUMBER

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## ABSTRACT

Borates have been used to preserve wood products for over 50 years. Currently, in the absence of a 'fixed' borate, the potential applications for wood products treated with boron are limited by their ultimate end-uses. However, with the trend toward the use of more 'environmentally sound' materials there has been a renewed interest in wood preservation with borates. This class of diffusible wood preservatives exhibit low mammalian toxicity while being highly toxic to wood destroying organisms. They offer the potential for helping to create a 'value added' product with some of the difficult to treat Canadian species which possess high %MC in their heartwood.

## INTRODUCTION

A number of recent trends are driving the development of new wood preservatives in the 1990's. Among those highlighted by Vinden[1] were: changing building practices (possible discontinuation of soil poisoning for termite control), increased need for value added production, conservation of resources and research into new wood composites. These issues all have relevance to the current development of boron based wood preservatives.

These preservatives are all derived from naturally occuring borate minerals. Probably the most commonly used form of boron for wood preservation is the compound Disodium Octaborate Tetrahydrate ($Na_2B_8O_{13}{\cdot}4H_2O$); it exhibits high water solubility and has a near neutral pH. Historically, boric acid ($B(OH)_3$) has also been used (*vida infra* ) although its lower solubility and pH have made it a less desirable preservative. Borates possess a number of properties that help to make them unique alternative wood preservatives:

- Inorganic salts (nonvolatile)
- Low mammallian toxicity
- Highly toxic to insects and fungi
- No insect resistance
- Odorless
- Colorless
- Noncorrosive

When used correctly they can give effective long term treatment that is also economical and environmentally sound.

Borates are members of a class of waterborne chemical preservatives which are diffusible in wood. Using the available moisture in unseasoned wood, the chemical redistributes itself after the treatment - diffusing from areas of high concentration (of chemical) to areas of lower concentration. The water soluble chemical 'equilibrates' in such a way as to eliminate the concentration gradient. This capability for the chemical to diffuse after treatment makes it possible to completely penetrate unseasoned wood, thereby allowing effective treatment of refractory species. The rate of diffusion is a function of both moisture content and temperature. In general it is thought that a minimum moisture content of ~35% is necessary for a practical rate of diffusion to occcur.

The water soluble nature of borates and the concommitant ability to diffuse is responsible for the limited end-uses compared to conventional preservatives. In spite of ongoing worldwide research, there is not yet a 'fixed' (unleachable) borate which has been shown to be efficacious in field tests. Without an available mechanism for locking the boron in the wood (or at least reducing the leaching characteristics) these compounds cannot be used for end-uses involving ground contact or unprotected outdoor exposure. These limitations are delineated in the American Wood Preservers' Association (AWPA) Standard for the treatment of Southern Yellow Pine with Borates: "C31-91 - Lumber used out of contact with the ground and continuously protected from liquid water - treatment by pressure processes".[2] While the goal of a completely fixed borate preservative remains elusive, it may still be possible to expand potential end-uses of borate treated wood by reducing the leaching characteristics and/or coating the wood. For example, in New Zealand borates have proven effective for years in above ground, exterior applications when protected by a three coat paint system.[3]

## DISCUSSION

The historical, world-wide development of borate based wood preservatives has been previously reviewed[4,5]. The initial development took place in Australia (1938) with the boric acid treatment of green hardwood veneers. This material was dipped in a heated solution of boric acid to protect the wood from attack by *Lyctus* borers. In a short time borates were also being used in New Zealand for protection against the borer *Anobium punctatum* . By 1952 the New Zealand Government had given approval for the treatment of wood with borax/boric acid mixtures (yields the same species in solution as the Octaborate compound, *vida supra* ) and in 1955 there were established commercial treating operations in place. Because of the requisite treatment of all building timbers in New Zealand, this country is currently the largest per capita consumer of treated wood products in the world. In 1986, borates were used to treat ca. 30% of the $1.7 \times 10^6$ $m^3$ of *Pinus radiata* that was preserved at treating plants in New Zealand.[6]

There has also been significant development over the years in Europe and the U.K. Early in the 1960's there was an initial effort to introduce boron treated building timbers into the United Kingdom.[5] This material was treated in the timber producing countries, Canada and Finland. Because of the time period required for diffusion and transportation there were problems with the supply and stocking of treated timber - customers were unable to get the material on an 'as needed' basis. The situation was clearly not acceptable and this early marketing effort failed; but supply problems aside, the positive attributes of borates has led to their current wide use as a remedial treatment in Europe and the U.K. .

Wood preservation with borates is currently being carried out on a worldwide basis: New Zealand (protection from beetles) and Australia (beetles and more recently termites), as well as the treatment of rubberwood in Thailand, Malaysia and Indonesia for protection against the Powder Post Beetle. In the United States borates are used as both a remedial treatment and in the preconstruction treatment of building timbers. In Canada borates are currently registered for the dip treatment of green lumber; a revision of the label to include pressure treatment is currently in the re-registration process (12/92).

In New Zealand, the commercial treating industry has been using borates for nearly 40 years. The Radiata pine is treated using the dip diffusion method. Bundles of green lumber are dipped in a concentrated borate solution (~25% w/w as Octaborate heated to ~35 °C) for 2-3 minutes. Typically a sapstain control chemical and a red dye are added to the treating solution; the dye is used for inventory control, helping to differentiate treated from untreated material. Once the material has been treated, the bundles are stored under tarps for the diffusion period, approximately 6-8 weeks; the length of the diffusion period is a function of moisture content and temperature- higher %MC and temperatures will both increase the diffusion rate.

A common misconception is that small amounts of moisture will readily leach boron out of the wood - this is simply not the case. In order for leaching to occur there needs to be a situation where liquid water is entering the wood at one point and then leaving the wood at some other point, *also as liquid water* . An attempt to illustrate how difficult this can be is shown with the following data on borate treated *Douglas fir* . This material was analyzed for boron in a 0.0"- 0.6" assay zone after exposure to different amounts of simulated rainfall.[7]

| Simulated Rainfall (inches) | % Boron Remaining |
|---|---|
| 0 | 100 |
| 14 | 100 |
| 35 | 82 |
| 88 | 75 |

In addition to dip diffusion, borate preservatives can also be applied using pressure treatment or a recently developed application technique, vapor boron.[8] The vapor boron method uses trimethyl borate, $B(OCH_3)_3$ , to treat wood which has been dried to 4-6% MC. The trimethyl borate is introduced under reduced pressure and reacts with $H_2O$ in the wood to yield boric acid and methanol; the methanol is pumped off and recovered, yielding kiln dried, borate treated wood. This method shows potential in the treating of composite material.

Borates are also being used for the remedial treatment of wood in service. The chemical may be sprayed or brushed on as a solution or applied as a solid in the form of a rod or paste.[9]

Products used worldwide include: TIM-BOR® ( Disodium Octaborate Tetrahydrate), DIFFUSOL® (aqueous based, concentrated borate solution with a thickener), BORACOL® (glycol based, concentrated borate solution). The solid, anhydrous disodium octaborate rods used for remedial treatments are distributed under the names TIM-BOR Rods (in the United Kingdom) and IMPEL® Rods (outside the U.K.).

There already exists a number of Standards which cover the use of boron based wood preservatives. In New Zealand, the Timber Preservation Council H1 Specification stipulates 0.1% w/w Boric Acid Equivalent (BAE) in the core (inner 1/9) of 90% of the samples being analyzed.[3] This Standard is for softwoods, primarily Radiata pine, and provides an adequate retention to protect against wood boring beetles. The Standard also specifies a 3.4 kg/$m^3$ BAE minimum total retention in the entire cross-section. In the United Kingdom, BWPDA Standard 105 also requires 0.1% w/w BAE in the core (inner 1/9) and a minimum of 0.4% BAE in the cross-section.[10] The AWPA Preservative Standard suggests a loading of 0.17 pcf $B_2O_3$ in a 0.0"- 0.6" assay zone; this higher retention (equivalent to 0.9% BAE w/w for Southern Yellow Pine) provides adequate loadings to protect against termites. With regard to Canadian status, there is currently an active task group in CSA-080 considering adoption of a Borate Preservative Standard.

In the absence of a fixed borate, one of the ideal end-uses for borate treated material is framing lumber used in the construction of homes and buildings. This wood is not in ground contact (slab or crawl space consruction) and can be protected from the weather. When properly treated and utilized this wood will be protected from fungal decay and insect damage for the life of the structure. Borate treated lumber has been used in this manner for ~40 years in New Zealand and there is essentially no need for remedial treatment of wood in service in that country. This is in marked contrast to the situation in the United Kingdom where over $265 million worth of insect- and decay-damaged timber is replaced annually.[1] Comparable figures in the United States for the annual prevention/control of subterranean termites are given as $1.5 billion(data from the 1960's).[11]

The subterranean termite *Coptotermes formosanus* is already well established in Hawaii and has recently been found in the Southeastern United States. Because of the extreme threat this termite presents to structural lumber (estimated damage of $60 million in Hawaii in 1990)[12] it is a requirement that all of the material in Hawaii be preservative treated. Douglas fir pressure treated with borates has recently been introduced into the Hawaiian market, presenting an alternative to CCA and ACZA (Copper Chrome Arsenate and Ammoniacal Copper Zinc Arsenate, respectively).

Field tests evaluating the efficacy of borate treated D. fir with C. *formosanus* have been conducted by researchers at the University of Hawaii.[13] Treated samples were evaluated in an above ground test, protected from the weather, that was placed directly on top of an active Formosan colony. The test chambers consisted of untreated D. fir boards and feeder stakes in addition to the treated material. After nearly 6 months of feeding exposure the samples with the highest retention (0.9% w/w Disodium Octaborate Tetrahydrate) exhibited only minor weight loss (ca. 2%). This feeding was primarily from surface attack and was described as 'cosmetic damage' since the structural integrity of the boards remained intact. Additional field tests evaluating higher retentions (closer to those on the surface of treated wood) have shown even lower weight losses.

The relatively high %MC in the Canadian softwoods Western Hemlock and *Amabilis fir* make them ideally suited for preservative treatment with borates. The average heartwood moisture contents in these species can be upwards of 80%. Treatment with borates, followed by a diffusion period could yield a value added product whereby even large dimension pieces have achieved through and through treatement. Potential markets for this material are the United Kingdom, Hawaii and South Florida as existing standards and code approvals are already in place. Eventual introduction into Japan and the Pacific Rim is also possible once existing standards are modified - borates already have approval for insect control (but not termites) in Japan. Research into the areas of accelerated treatments (with the intent of reducing the necessary diffusion period) and specific tests involving Japanese commodities (to collect the data needed for inclusion into the standards) is currently ongoing at the Forintek Western Laboratory. It is hoped that preliminary results will be presented at next years's CWPA Meeting in Vancouver.

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