# WOOD PROTECTION WITHOUT CHLOROPHENATES

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Our keynote speaker started the morning by talking about adding value to wood and no-one can doubt that is a positive move. Unfortunately the area I will be talking about is often interpreted as negative in that it is concerned with not subtracting value. At Forintek we prefer to take the positive view that we are assisting the industry to enhance the value of our export lumber.

Today I'm going to discuss wood protection, which we define as the short-medium term protection of wood from biological agents. After some economic background I will explain the nature of the Canadian wood protection. I'll also talk about drying and about chlorophenates and why they were most useful but are now part of history. I will discuss chemical products currently available for antisapstain use and what some of their limitations, compared to the perfect product, might be. I'd also like to cover efficacy and environmental problems associated with use of such products.

## Economic Background

Surrounded as we are by the forests of British Columbia it may be redundant to stress the economic importance of wood to the provincial and Canadian economies but for the benefit of visitors I will do just that. Forest Products are Canada's largest earner of export income each year contributing about $14 billion to our balance of trade. Canada is the world's largest exporter of softwood lumber and 60% of the total Canadian annual production, of some 50 million $m^3$, of lumber comes from B.C. Provincial exports represents 40% of world-wide trade in softwoods. As you all know there is a gradual substitution of temperate softwoods for tropical hardwoods. This implies that the market for Canadian softwoods will remain buoyant.

Lumber shipments from B.C. have the following destinations: half goes to the USA, a third is sold in Canada and the remainder shipped offshore mainly to Japan, the UK, Europe, Australia and Africa. The Council of Forest Industries, of B.C. continues to successfully pursue offshore markets for B.C. softwoods. It is imperative that this wood, particularly the wood shipped overseas in green condition, be of the best possible quality when it arrives in the customers' hands - that is value-enhanced.

## Biological Background

Because of its origin wood is a naturally biodegradable material. So long as it contains moisture over about 25% it will be subject to attack by

fungi. The fungi which cause most damage to shipments of lumber are the moulds and staining fungi. These fungi live mainly on the sugars within the wood which are most abundant in the sapwood. Unlike the wood decaying fungi, which we normally try to control through wood preservation, they have little effect on the strength of the wood. However decaying fungi do cause problems during shipment over a longer term and as their name implies they do weaken and eventually they destroy wood.

Fungi reproduce via spores. Once a spore reaches the wood surface it can germinate if conditions are right. It will not grow into the wood if the wood is dry or if it has been protected by a chemical treatment which will prevent the fungus from developing. Protection can be therefore achieved by two methods - by drying or by chemical treatment.

**Kiln Drying**

You may ask why we don't dry all our wood and have done with the fungal problem? There are complex answers to this simple question depending on the type of wood, its size, the method of transportation and markets.

The first thing to note is that drying incurs extra handling, and additional energy costs. Some lumber loses value during drying due to degrade and these costs have to be covered by the additional revenue one is able to obtain from customers for the dried product.

A second point is that drying wood does not entirely get rid of the risk of fungal degradation, for the simple reason that the wood does not always stay dry. Even after drying lumber packages are at risk of being rewetted at various stages: in the mill yard, on the railcar, at export terminals, on the deck or in the hold of the ship. Many mills wrap dried lumber in paper or plastic. Unfortunately wrappers become torn and therefore no longer do the job of protecting against rainwater. On this slide (figure not available for publication) you can see the effect that rainwater percolating into the package, in this case through a few staple holes, can have on the otherwise well dried wood. The moisture has enabled moulds to grow vigorously. To guard against this type of problem exported kiln-dried stock is sometimes therefore also given a fungicide treatment to protect it. With increased concern for quality in the market I would not be surprised if more kiln-dried material is chemically treated in the future to guard against this problem.

Thirdly I mentioned the importance of wood species, size and methods of transportation. Spruce-Pine-Fir from B.C.'s interior is naturally drier than most coastal woods and is cut into relatively small sizes which can be kiln dried easily. There is an economic advantage in drying because railways charge by the weight of the shipment and drying therefore also minimizes transportation costs.

In coastal B.C. hem-fir lumber is a major product. Hemlock is a naturally wet wood and kiln drying is expensive because of especially high energy requirements and also because hem-fir has to be dried relatively slowly to minimize drying defects. For the larger dimension stock, which will usually be resawn at its destination, kiln-drying is not technically

usually be resawn at its destination, kiln-drying is not technically feasible. Large dimension, high value, stock is a significant portion of coastal production. Furthermore because ship freight is charged by the volume of a cargo rather than its weight, there are no shipping advantages to drying. Hem-fir export lumber is therefore usually shipped close-piled with high potential for biodeterioration during storage and shipping. A good chemical protection is routinely required on this product.

No doubt there is a discernable trend towards more drying but we would have to conclude that drying is not the answer to our problem and there is still a need for a substantial amount of lumber to be chemically treated in B.C. Lumber with an estimated annual sales value of $2.1 billion needs chemical antisapstain protection. Because of the length of time this lumber may take to reach overseas buyers, there is an industrial requirement for protection to be effective for 12 months from the time of manufacture.

## Chlorophenates and Alternatives

I've titled this talk wood protection without chlorophenates so I had better give brief mention to what will come to be known as the chlorophenate era. This began in the 1930's when the lumber industry embraced this modern chemical wonder for protecting wood. The chlorophenate era lasted over 50 years, basically until 1988.

At the 1987 CWPA (1) meeting I went into the reasons why chlorophenates were able to dominate in the industry but I think it's worth reflecting on them again. Five reasons come to mind:

1. Chlorophenates will control most problem fungi (except brown moulds).
2. They are cheap chemicals.
3. They are flexible in use - because of their broad spectrum of activity they work on all wood species and for any reasonable protection period.
4. They are technically easy to use.
5. They have a proven track record.

Chlorophenates were quite up to the increasingly tough job required of them during this time - increasingly tough because of changes in shipping practices and because of higher quality standards.

Mainly because of their environmental persistance, and the presence of trace amounts of dioxins, pressure mounted on the chlorophenates and in 1988 they began being phased out from use. This left the industry with a choice of just two products which had old registrations - PQ-8, a formulation of copper-8-quinolinolate (Cu-8), and several formulations of TCMTB.

Two new products were registered in 1988 - Ecobrite, based on sodium carbonate/borax in a ratio of approximately 8.5:1, and Nytek GD, a neutral Cu-8 formulation. These were welcome additions to the menu of products available for industry.

Now a few words about the perfect antisapstain product: we all know the perfect product hasn't yet been discovered but it is worth reflecting on what characteristics it would have. We require a product which will (in no particular order):

- be effective against all the problem fungi
- give a 1 year shelf life to green treated lumber
- be environmentally acceptable, in particular having a low fish toxicity
- be user friendly - safe to use around the mill
- be easy to handle in the mill that is from a machinery point-of-view be non-corrosive and compatible with other mill materials
- be acceptable to all of our customers, for example it should not adversely colour the wood and the chemical should cause no problems with customer use or handling
- be cost effective. The current range of chemical costs appears to be about $1 - $5 /Mfbm.

The relative importance of these factors has varied with time. Right now the environmental friendliness aspect of the chemicals has understandably leapt to the top of most peoples' list of desirable attributes. There is a danger though that in the quest for the most environmentally friendly products we lose sight of the reason we are using the chemicals.

## Efficacy

Over the years Forintek and the forest products industry have invested a lot of resources into the identification and subsequent testing of a large number of antisapstain formulations, both the registered ones and completely new products. Testing has focussed on to determining their efficacy or how well they work. Of course there is no point testing products which are going to be harmful to workers, and products should be as environmentally benign as possible. We have always started from the premise that firstly we have to show that the products work, and preferably work as well as, or better than, the chlorophenates.

Unfortunately most non-chlorophenate alternatives have often proved more selective regarding the fungi they control, they are relatively expensive, they are less flexible with respect to species and protection requirements, there have been technical difficulties in their application and a long term track record has not yet been established in Canadian mills. Unlike the chlorophenates there is often not a clear dose/efficacy response. With some products there appears to be an efficacy plateau which is a little below the level of protection we would like.

Figure 1. gives an example of the type of efficacy data Forintek generates on behalf of the industry. This data is from a trial where hem-fir lumber was treated in a sawmill spray system with the concentrations of the products you see on the bottom axis. The relative acceptability of the wood six months after treatment is shown. We think that 90% acceptability is a good target for common grades of wood but it should be higher for higher grades, and as the importance of selling a high quality product

becomes more critical. You can see the difficulty reaching these target protection levels with certain of the products tested here. Also shown in Figure 1 are the percentage of pieces totally clean for each treatment.

Good efficacy data allows us to determine the amount of chemical required to protect wood. We measure chemical treatment levels in terms of the number of micrograms of active ingredient required per $cm^2$ of wood surface. The approximate retentions required for maximal levels of protection for the four registered products are approximately as follows:

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|---|---|
| Chlorophenates | 50 micrograms/$cm^2$ |
| Cu-8 Nytek | 15 |
| PQ-8 | 5 |
| Ecobrite | 900 |
| TCMTB | 40 |

These are not necessarily the levels required for equivalent efficacy for the simple reason that, with some products, we cannot always achieve the efficacy levels we obtained with chlorophenates. You will note the wide range in amounts of chemical required and two basically different approaches to the protection problem. With Ecobrite we are looking at large doses of chemicals which are less toxic to fungi, while with the other products we are looking at much smaller amounts of fungicide which are more potent.

Despite the fact that they are based on the same active ingredient the target retention levels of Nytek and PQ-8 are different and this raises the important issue of formulation. We tend to focus on the chemical (active ingredient) in these products. In fact the method of formulating an active ingredient is often as important as the active itself. Formulation is critical to the way the active is presented to the pest, to the formation of the deposit on the wood, to its diffusion into, and its leachability from, the wood. Formulation is also critical to toxicological and to environmental effects. I make this point because I think many people tend to overemphasise the nature of the active ingredients themselves.

I would now like to mention the subject of formulating mixtures of chemicals. Mixtures may show the advantage that the efficacy of the whole can be greater than the sum of the efficacy of the parts, they can be targeted to the particular needs, and they may be adjusted to cope with changing conditions. (Data presented - unavailable for publication).

The net result of using mixtures is that we can end up with LESS CHEMICAL on the wood to do the job and this has important implications - for the environment, for handling and for economics. We are starting to see practical use of two component mixtures using narrower spectrum fungicides - Ecobrite and NP-1 are good examples. These are just the start of a third generation of antisapstain products and we could look ahead to a fourth generation which might involve three less toxic active ingredients.

Optimization of efficacy with a three component system does become complicated though.

An additional problem is that the data requirements for registration under the Pest Control Products Act are even more formidable for multi-component products than for formulations of single active ingredients. Registration of any new antisapstain product is, from the point of view of the forest industry, frustratingly slow. This situation is the subject of current discussions between interested parties and Federal Government agencies. A draft Federal Government "Discussion Document on Antisapstain Chemicals" authored by five government departments has recently been released to be the starting point for discussion on the registration process.

## Environmental Considerations

The topics of environment and worker safety quite rightly are brought up time and time again in the context of sapstain control. At Forintek we have tried to work only with products that would be safer to use and kinder to the environment than some traditional fungicides. Toxicology is not our area of expertise so we have to rely on others, particularly the Federal Government for advice there.

In this province, where most sawmills are located alongside bodies of water, leachability and fish toxicity of chemicals from antisapstain treated wood is an important subject. Following discussion between industry and government regulators guidelines have now been established which limit the levels of antisapstain chemicals permitted in mill yard runoff. These levels have been set at 200 parts per billion for TCMTB and for copper-8, until Sep 1 1990, at which time the maximum allowable levels will decline to 15 ppb for both chemicals. (Just to put that in perspective for example for TCMTB we are talking about the equivalent of one drop of chemical concentrate in four - 45 gallon drums). These are tight regulations indeed and they are based on the fish toxicity (lowest 96 hr $LC_{50}$ for salmonids) of the chemicals which are approximately:

| | |
|---|---|
| NaPCP | 32 ppb |
| Cu-8 (Nytek) | 13 ppb |
| Ecobrite | 500,000 ppb |
| TCMTB | 15 ppb |

These figures for fish toxicity are approximately the lowest (i.e. highest toxicity) levels reported for rainbow trout. The contrast between the very low fish toxicity figures for Ecobrite and considerably higher toxicity for other products is quite apparent.

Fish toxicity is not the sole determinant of the extent of the leachate problem. The toxicity of yard runoff to fish depends on various factors which have not been fully investigated. For example it would vary with the amount of treated stock in the yard, and the level of treatment of the

wood; presumably the more chemical applied, the higher potential for leaching. Additionally products will leach at different rates depending on the solubility of the active ingredients, the product's affinity for the wood surface and the way it is formulated. Of course different components of a mixture might also be expected to have different, possibly totally different, leaching characteristics.

To get a baseline level of the leachability of an antisapstain chemical we have developed at Forintek a simple test in which packages treated with a known level of a product are leached using artificial rain. The leachate is collected and analyzed for the chemicals being leached. Figure 2. shows data generated for sodium borate which we used to refine details of the test before we did it on real products. You will see the levels of sodium borate decrease with time and this is similar to the data we generated for chlorophenates when Forintek first did some testing of the leaching problem several years ago. The lower curve represents what happens if you allow the borate treated wood to sit for 24 hours prior to leaching. In this case we are dealing with a highly water soluble chemical which gradually diffuses into the wood and over time less becomes available for leaching, hence the decline in the total chemical leached. We did not find this to be the case with chlorophenates where storage periods made little difference to the amount of chemical leached off.

This method we use to compare the leachability of formulations, for example, if a formulator wishes to see the effect on leachability of adjuvants which might limit the problem.

One of the difficulties we have found in doing leaching studies and that is the accurate analysis of leachate samples at the low levels required. It takes considerable work to develop accurate analytical methods for some of these chemicals and excellent quality control of the results is critical to obtaining good data.

On a practical level it will probably be very difficult to achieve the 15 ppb levels for TCMTB and copper-8 without formulation modification, which might require re-registration of the new formulations. Completely (physically) covering the treated packages is hardly a feasible alternative and therefore modification of registered formulations to limit leaching is a challenge now facing the formulators.

**Summation**

I think all who are involved with antisapstain chemicals agree that things have recently been moving incredibly quickly - quicker than we believed could possibly happen. A couple of years ago everybody was using chlorophenates to protect wood; there were two expensive alternatives with little track record, available as alternatives. Kiln drying can never be a solution to the problem. The forest industry has switched to its limited menu of registered products all the time hoping that more products would become available and thereby overcome the technical problems and efficacy problems and latterly leachability problems which it has encountered.

As industry has been switching away from the chlorophenates the marketplace has been getting more and more quality conscious and safety and environment have become increasingly important. We wonder whether chlorophenates, used at their traditional levels would be able to do the protection job which is becoming increasingly demanded.

However there is a lot of work going on in making more efficient chemical formulations and in more efficient ways of applying these chemicals. Although it poses a severe challenge to those who formulate and those who use antisapstain products both the chemical industry and the forest products industry are working very hard. The goal is safe and effective wood protection without chlorophenates.

## Reference Cited

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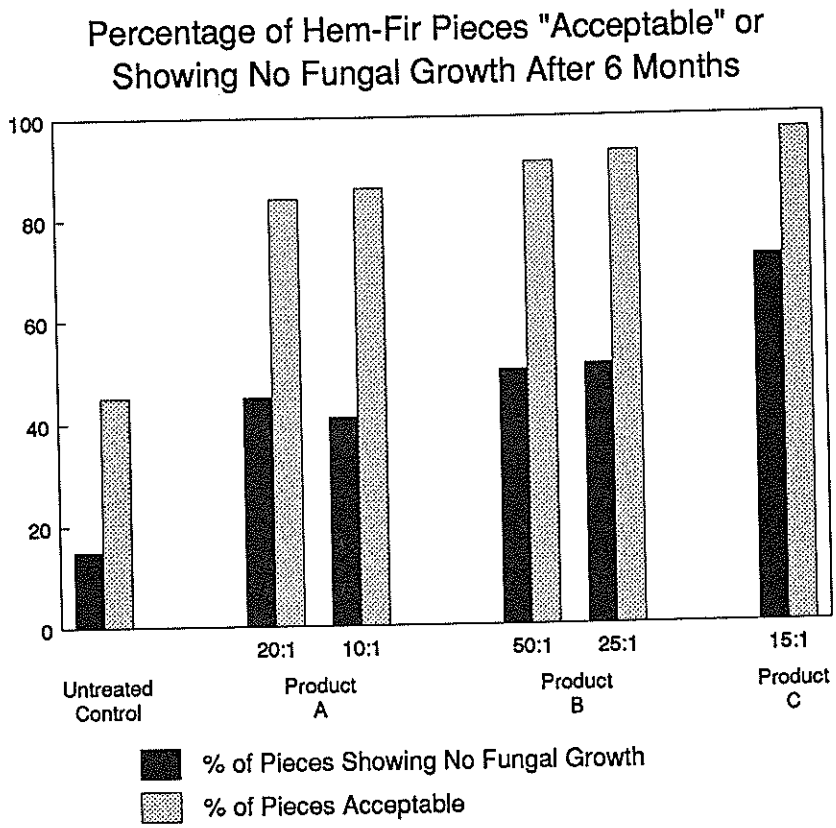
Percentage of Hem-Fir Pieces "Acceptable" or
Showing No Fungal Growth After 6 Months
100
80
60
40
20
0
20:1
10:1
50:1
25:1
15:1
Untreated Control
Product A
Product B
Product C
% of Pieces Showing No Fungal Growth
% of Pieces Acceptable

Fig. 1

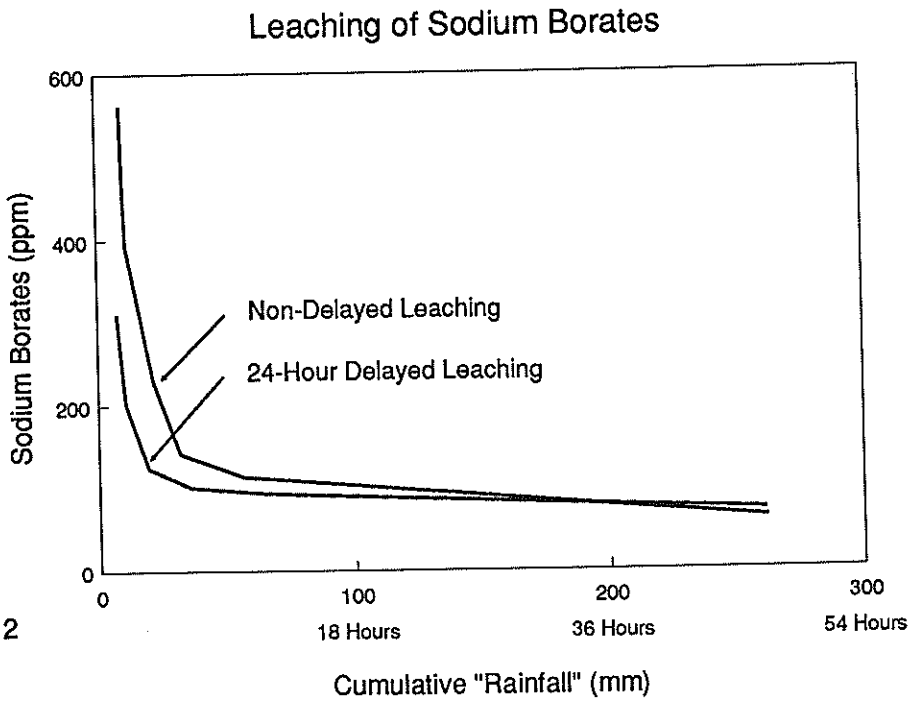
Leaching of Sodium Borates
600
400
200
0
Sodium Borates (ppm)
Non-Delayed Leaching
24-Hour Delayed Leaching
0
100
200
300
18 Hours
36 Hours
54 Hours
Cumulative "Rainfall" (mm)

Fig. 2