CURRENT RESEARCH IN WOOD PRESERVATION

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INTRODUCTION

In recent years, the wood preserving industry has been faced with a number of challenges that have been addressed by research workers, both in industry and in the various institutions involved in wood preservation research. This has been true in Canada, and also in other countries. The challenges have included the rapid emergence of a new level of concern about the environment. This has required research and development effort to find cost-effective technology for reducing environmental impact and for meeting such requirements as effluent-discharge standards. Another response to the same challenge is the continuing search for new chemical systems and new approaches for the protection of wood against biological attack. Increasing costs for petrochemicals, and supply problems, have increased interest in water-borne preservatives and in ways of reducing oil requirements for pentachlorophenol treatments. Fuel costs have been the stimulus for work aimed at reducing the amount of secondary drying associated with water-borne treatments. Concern about the availability of poles and ties has prompted studies of alternate pole species and of alternate ways of producing railway ties. Other research activities have included studies of the treatabilities of various species and products, the development of service data, studies of preservative migration, depletion and distribution, development of accelerated test methods, improvement of standards and many basic studies of biodeteriorating agents.

The whole range of activities that could be considered as being part of wood preservation research will not be covered here. Instead, some general categories will be considered, and examples will be given of developments that have had, or could have, an impact on present products and processes in Canada. In addition to developments from Canadian research, some from the United States and from other parts of the world will also be included.

ENVIRONMENTAL TECHNOLOGY

This is an area of activity that formerly might not have been considered as being part of wood preservation research. However, the realities of today dictate that the protection of the environment must be ranked at least as highly on the industry's list of priorities as the more traditional research goals. In North America alone, many man-years of effort have gone into the development of environmentally-related data on the chemicals the industry uses, their trace impurities, their degradation products and their products of metabolism. Data have also been obtained on the impact of operations in treating plants, and concerning treated products in use.

In 1977, a joint Environmental Protection Service wood protection industry seminar was held in Toronto to discuss the status of the industry with respect to aqueous discharges. At that time, Domtar's experience with activated carbon adsorption was described (1). Since then, flocculation has been found to be an effective way of reducing organic contaminant levels prior to carbontreatment, and this sequential approach is currently being used at four plants.

The Environmental Protection Service is now in the process of obtaining data to identify "Best Practicable Technology" and has recently conducted a study at the Northern Wood Preservers Limited plant in Thunder Bay to assess the effectiveness of an activated sludge, and carbon-treatment system (2). The biological system was found to be effective on all organic contaminants, with the exception of pentachlorophenol. Although this material was found to be subject to biodegradation, removal levels averaged only 35% under the conditions of the study. However, the biological treatment approach was found to be an effective means of reducing the load on a pilot-scale carbon adsorption system.

Domtar has considered other treatment technology for removing organic contaminants. These include wet air oxidation which is effective in destroying organic material in water, but which is very costly at present. Another approach is that of membrane technology. Membranes can efficiently remove emulsified oils from contaminated process water. These systems are also expensive, but offer the possibility of recovering preservative components for re-use. The most desirable treatment system would be one that is cost-effective and that also minimizes the production of solid wastes, sludges or other concentrates that require disposal.

WATER-BORNE PRESERVATIVES

The two standard water-borne preservatives used in Canada are CCA and ACA. For several years now, personnel at Forintek, Ottawa, have been working on ammoniacal preservative systems similar to ACA, but in which the amount of cation has been increased relative to arsenic. This modification increases the degree of fixation of the arsenic without detracting from the effectiveness of the preservative. The reason for working with ammoniacal systems was in order to develop treatments for refractory Canadian species such as spruce. The systems developed include copper arsenate with added copper, a copper arsenate system with added zinc, and a system containing only zinc and arsenate as the preservative components. Test plot data are showing that all the systems are effective preservatives, and the CSA Standards were recently changed to allow the use of a modified ACA system containing added copper. In addition to the preservative components, some formulations contain water-repellent additives such as carbonate, fatty acids and latexes. A review of ammoniacal preservative technology was recently presented by Hulme of the Ottawa laboratory (3).

In the field of CCA technology, a recent development is the "MSU" process, so-named because this treatment method was developed at Mississippi State University (4). The process enables a treater to use an empty-cell treatment with CCA. This was not possible before because the spring-back from an empty cell treatment would contaminate the treating solution with wood extractives. These would then reduce the preservative components and produce insoluble deposits in storage tanks. In the MSU process, the problem of spring-back is avoided by adding a fixation step at the end of the pressure period. Essentially, pressure is maintained on the charge while the treating solution is withdrawn and replaced by hot water. The hot water then speeds fixation of the preservative components in the wood. After the hot water is finally removed from the cylinder, still under pressure, a final vacuum is applied to remove excess liquid from the wood cells. As this liquid contains only trace amounts of preservative components, it is not returned to the treating solution. The advantage of this treating method is that the wood contains less water than if it had been treated by a full-cell process and therefore costs less to ship, or else requires less energy or time for drying.

OIL-BORNE PRESERVATIVES

The ever-increasing prices of petroleum solvents for pentachlorophenol treatments have an inevitable impact on treating costs. At times, the availability of these solvents can also be a problem. A recent development of Idacon Inc. of Houston, Texas (5) addresses these problems and shows promise as a means of reducing oil requirements by some 85% by dispersing a pentachlorophenol-in-oil concentrate in water and treating with the aqueous dispersion. The key to the process is the fine particle size and the stability of the dispersion, both of which are determined by the blend of preservative, hydrocarbon solvent, co-solvents and dispersing agent. The treated products are light in colour, relatively non-oily and the system has been shown to be comparable to pentachlorophenol-in-oil in terms of soil block and leach test results and in terms of preservative distribution within the cell wall. Based on the results of both experimental and commercial treatments in the U.S., there appear to be no problems in obtaining satisfactory penetration and retention in southern pine fence posts, lumber and poles, using this new pentachlorophenol system.

DEVELOPMENT OF NEW PRESERVATIVES

This is an active area of research at the present time, due primarily to concern about the possible environmental impact of the preservative systems now in use. Many compounds, both naturally-occurring and synthetic, are being investigated as candidate wood preservatives. Also, biological inhibition, biochemical approaches and modification of wood substance are being studied. Perhaps the most promising recent development in the field is the identification of alkylammonium compounds as candidate wood preservatives, due largely to work in New Zealand by Butcher and co-workers. A review of the previous work and some additional data were recently presented by Nicholas and Preston (6).

The alkylammonium compounds include tertiary amine salts and quaternary ammonium compounds. A variety of each is possible, depending on the nature of the substitutents on the nitrogen atom and the nature of the anion. The compounds are soluble in water, but are highly substantive to wood substance, becoming highly fixed after impregnation into wood. Apart from these advantages, they are also of low mammalian toxicity and are used in such domestic applications as fabric softeners and hair conditioners.

One of the peculiarities of the alkylammonium compounds is the strong affinity between them and wood substance. This can be controlled to some extent by adjustment of pH. In more acidic solutions, the affinity is less and it is then easier to achieve penetration into wood and into the cell wall. Laboratory and field tests against fungi and termites have shown some of the alkylammonium compounds to be very effective. However, sufficient data are not yet available to predict longterm effectiveness.

Canadian work with these compounds was recently reported by Ruddick (7) who is studying the compounds alone, and in combination with other preservatives. The effectiveness of quaternary ammonium compounds for control of stain has been reported by Hulme (8).

RAILWAY TIES

The railway tie has long been one of the major products of the wood treating industry and continues to occupy that position today. There has been some concern recently about the future availability of wood for production of ties, and some studies have been made of alternate methods of providing this product from smaller dimension lumber or comminuted wood. Approaches taken have included dowell laminating (9) and fabrication of ties as composite products (10).

At Domtar, a process was developed that could be used for commercial production of glu-lam ties using four pieces to give the 7" x 9" cross-section required by the railways. Although this type of tie is not yet in commercial production, glu-lam ties already have a long record of satisfactory service, based on the performance of some units made by Forintek, Ottawa, which have now been in service for thirty years.

The involvement of the Ottawa laboratory in tie technology extends over some forty years, during which time valuable service data have been compiled in collaboration with the railways on tie hardware, wood species, and preservative performance (11).

UTILITY POLES

Despite Canada's image as a country of abundant forest resources, in some years Canada is a net importer of poles. Some of the reasons for this have been discussed by Dobie (12). As our need to import poles could be reduced or eliminated by making greater use of native species such as spruce, studies of this species have been undertaken. The results of commercial treatments of white spruce poles in B.C., using both ACA and pentachlorophenol-in-oil have previously been reported by Ruddick (13). Some of these treated poles were used to obtain strength data and others have now been installed in a test plot to obtain data on the effects of incising and of kerfing on check-formation.

A current study on spruce poles in Eastern Canada involves the participation of Ontario Hydro, Hydro-Québec, Nova Scotia Power, the Canadian Electrical Association, Forintek and Domtar. The objective is to determine the performance and checking characteristics of white spruce poles in service in Ontario and Québec, and of red spruce poles in Nova Scotia.

One thousand poles were used in the study, using various cutting and peeling schedules because of the possible effects these might have on checking patterns. Half of the poles from each province were incised for the same reason. In addition, ten kerfed poles were included for installation in the Ontario Hydro test plot at Barrie.

Based on previous Forintek data on the treatability of spruce with ammoniacal preservatives (14, 15), and the expectation that a water-borne treatment would provide a more severe test of checking characteristics, ACA was used to treat eight hundred of the poles. The remaining two hundred were treated with pentachlorophenol-in-oil and accepted by Hydro-Québec so that oil and aqueous systems could be compared in that province.

Forintek personnel inspected the poles after initial seasoning, to assess the extent of check formation at that stage. They will now be monitoring the performance of the poles in service and reporting, in detail, the results of this collaborative study.

In other pole-related research, Ruddick has reported on the effectiveness of full-length kerfing in reducing check formation in untreated Douglas-fir pole sections (16). The deepest checks in unkerfed material were found to be 2.4 times greater than in kerfed material after almost four years of weathering. Another interest of the Vancouver laboratory is in electronic or sonic decay-detecting devices that could be used to assess the condition of poles in service or prior to treatment.

LUMBER AND OTHER PRODUCTS

As wood species with more-durable heartwood become less readily available, interest is increasing in methods of treating refractory material. Promising results from a study of the treatability of spruce lumber with an ammoniacal preservative were reported by Krzyzewski *et al* (14, 15). Incising, which is an effective technique for increasing the penetration of preservatives into refractory material, has been reviewed by Perrin (17) in terms of its effects on penetration, drying rates, checking and strength properties of a number of products. The effectiveness of incising in increasing the treatability of lodgepole pine lumber with ACA and CCA has been reported by Ruddick (18).

Experimental roof sections of western red cedar shakes are being exposed in the Haney, B.C. area to obtain information on the effectiveness of preservative treatments in extending the service life of this product. Data reported by Cserjesi (19) showed negligible losses of pentachlorophenol, ACA and CCA from the exposed surfaces of shakes after eight months of weathering.

BIODETERIORATING AGENTS

The study of fungi, insects and marine borers is a basic aspect of wood preservation research. Activities include fundamental studies of the organisms themselves, the development of laboratory and field data on the effectiveness of various combinations of preservatives and wood species, and the development of accelerated test methods. An area that has received much attention recently and which has been discussed by Levy (20) is that of soft rot. This type of attack occurs particularly in treated hardwoods and can occur under conditions that do not favour the growth of the more common wood-destroying fungi, such as in water-cooling towers. Studies on CCA-treated hardwoods by Hulme and Butcher (21), and by others, have suggested that very high loadings of preservative are necessary in order to ensure that adequate concentrations of copper will be present in the cell wall where this type of organism grows. Although soft rot can occur in softwoods, it is much easier to obtain suitable distributions of preservative components within the softwood cell wall and hence to prevent this type of attack.

Both laboratories of Forintek are involved in soft rot research. Part of this involves collaboration with laboratories in the U.S. in an AWPA task force effort to evaluate accelerated test methods that could be used in further studies of this type of decay.

CONCLUSIONS

Wood preservation research is continuing to respond to the needs of both the treating industry and the users of treated wood products. Despite the challenges presented by environmental concerns and changes in the costs and availability of raw materials, solutions are being actively sought and identified by the application of research effort in relevant programs. Through continuation of this type of effort, preservative treatment of wood should continue to serve in its role of conserving a valuable resource while providing a versatile, durable material at energy costs well below those of available alternatives.

REFERENCES

1. Richardson, N.G., 1978. "Wood Preserving Effluents and Their Treatment", The Timber Processing Industry – Seminar Proceedings, Environmental Protection Service Report No. EPS 3-WP-78-1, Environment Canada, Ottawa, 40 – 62.

2. Guo, P.H.M., Fowlie, P.J.A., Cairns, V.W. and Jank, B.E., 1980. "Activated Sludge and Activated Carbon Treatment of a Wood Preserving Effluent Containing Pentachlorophenol", Environment Protection Service – Technology Development Report No. 4-WP-80-2.

3. Hulme, M.A., 1979. "Ammoniacal Wood Preservatives", Record of the Annual Convention of the British Wood Preserving Association, 38 – 48.

4. Appendix to Committee T-4 Report, 1978. "The MSU Process", Proceedings of the American Wood Preservers' Association, 74: 42 – 54.

5. Hatcher, D.B., 1980. "Dura-Treet II, a Water Dispersible Pentachlorophenol", Proceedings of the American Wood Preservers' Association, 76: 308 – 320.

6. Nicholas, D.D. and Preston, A.F., 1980. "Evaluation of Alkyl Ammonium Compounds as Potential Wood Preservatives", Proceedings of the American Wood Preservers' Association, 76: 13 – 20.

7. Ruddick, J.N.R., 1980. Wood Preservation Research in Canada. Proceedings of the American Wood Preservers' Association, 76: 191 – 204.

8. Hulme, M.A. and Thomas, J.F., 1979. "Control of Fungal Sap Stain with Alkaline Solutions of Quaternary Ammonium Compounds and with Tertiary Amine Salts", Forest Products Journal, 29(11): 26 – 29.

9. Bescher, R.H., 1979. "The Merits of Dowelled Laminated Ties vs. Solid Sawn Ties", Proceedings of the American Wood Preservers' Association, 75: 60 – 64.

10. Anonymous, 1974. "Santa Fe Sets Service Test of Reconstituted Tie", Railway Track and Structures, 70(10): 18 – 19.

11. Krzyzewski, J., 1977. "Performance of Preserved Railway Ties", Canadian Forestry Service, Eastern Forest Products Laboratory Report No. OPX183E.

12. Dobie, J., 1976. "Are we Losing the Pole Market?", Canadian Forest Industries, 96(7): 44 – 46.

13. Ruddick, J.N.R., 1978. "Preservative Treatment of White Spruce Poles", Canadian Forestry Service, Western Forest Products Laboratory Report No. VP-X-176.

14. Krzyzewski, J., Rak, J., and Hulme, M.A., 1979. "Industrial Trials with Ammoniacal Preservatives, Part I", Canadian Forestry Service, Eastern Forest Products Laboratory Report No. OPX223E.

15. Krzyzewski, J., Rak, J., and Hulme, M.A., 1979. "Industrial Trials with Ammoniacal Preservatives, Part II", Canadian Forestry Service, Eastern Forest Products Laboratory Report No. OPX224E.

16. Ruddick, J.N.R. and Ross, N.A., 1979. "Effect of Kerfing on Checking of Untreated Douglas-fir Pole Sections", Forest Products Journal, 29(9): 27 – 30.

17. Perrin, P.W., 1978. "Review of Incising and Its Effects on Strength and Preservative Treatment of Wood", Forest Products Journal, 28(1): 27 – 33.

18. Ruddick, J.N.R., 1980. "Treatability of Lodgepole Pine Lumber with ACA and CCA", Forest Products Journal, 30(2): 28 – 32.

19. Cserjesi, A.J., 1976. "Permanence of Preservatives in Treated Experimental Shake Roofs", Forest Products Journal, 26(12): 34 – 39.

20. Levy, C.R., 1978. "Soft Rot", Proceedings of the American Wood Preservers' Association, 74: 145 – 163.

21. Hulme, M.A. and Butcher, J.A., 1977. "Soft-Rot Control in Hardwoods Treated with Chromated Copper Arsenate Preservatives", Material and Organismen, 12(3): 223 – 234.