Potential of didecyldimethylammonium tetrafluoroborate (DBF) as a novel wood preservative

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Although chromated copper arsenic (CCA), the most effective and widely used wood preservatives in the past, had been a dominant wood preservative since it was develop in 1933, the use of CCA was recently banned or restricted in most of countries in the world, *e.g.* USA, Canada, Japan and Europe (1 - 3). Since CCA contains environmentally unfriendly heavy metals, it is quite natural for alternatives to replace that.

Chemical treatment is still the most reliable measure to ensure the longer service life of wood products with the aid of improved microclimate in the crawlspace of houses. Alkylammonium compounds (AAC's) such as didecyldimethylammonium chloride (DDAC), are one of the groups which are provided with low mammalian toxicity and environmental soundness (4). A novel didecyldimethylammonium tetrafluoroborate (DBF) (5, 6), one of the AAC's recently appeared in the market. However, little is known about its ability to protect wood from biodegradation. DBF is chemically constituted by a fungicidally effective alkyl chain (C_{10}-C_{10}) and water stable tetrafluoroborate (BF_4^-) as a counter ion. In this study, DBF was evaluated for its efficiency in protecting wood from decay fungi, subterranean termite and drywood termites. In addition, leachability of DBF from the treated wood and combined effect of DBF and wood extractives. The results were compared with those of the commercial wood preservative, DDAC.

Although microbial test showed that DBF was effective in inhibiting the microbial growth on the sapwood specimens of *Cryptomeria japonica* D. Don. and *Fagus crenata* Blume at ≥0.5-1%, and that DBF was superior to DDAC, it was concluded that DBF was not promising as a superficial protectant. Because decay and termite tests demonstrated that brush-on treatment did not meet the performance requirement of ≤3% mass loss (7) after accelerated aging cycles.

In the vacuum-impregnation treatment with DBF and DDAC, several wood species with different natural durability were treated at several retention levels, and then were served for the decay and subterranean termites test according to JIS K 1571 (7). Decay test using *Trametes versicolor* (L.:Fr.) Pilat (FFPRI 1030) and *Fomitopsis palustris* (Berk. Et Curt.) Gilbn.&Ryv. (FFPRI 0507) indicated that the toxic threshold values differed among wood species, *e.g.* in the case of DBF retention, 0.7-3.6 kg/m^3 in the heartwood of *C. japonica* and *Chamaecyparis obtusa* Endl., >6.5 kg/m^3 in the sapwood of *F. crenata*. DBF was proved to be as effective as DDAC in controlling fungal attack. The resistance against *Coptotermes formosanus* Shiraki was much enhanced by DBF impregnation and the lower DBF retentions were required to satisfactorily suppress termite activity. The required retentions of DBF were varied with durability levels of each wood species, and ranged from <0.07 kg/m^3 to 4.00 kg/m^3. Efficacy of DBF in controlling *Incisitermes minor* Hagen, western drywood termite activity as high as that of DDAC, and the required retention levels were >1.72 kg/m^3 and >4.50 kg/m^3 of DBF and DDAC for sapwood and heartwood of *C. japonica*, respectively.

Leachability of DBF was determined by chemical anslysis of the amount recovered from treated wood such as sapwood of *C. japonica* and *F. crenata* and heartwood of *C. japonica, C. obtusa*, *Pseudotsuga menziesii* (Mirbel) Franco and *Tsuga heterophylla* Sarg. after leaching and evaporation cycles. The results were compared with those of DDAC. Leachability was varied with wood species as expected and preservatives. DBF was generally more resistant against water leaching than DDAC after severe weathering cycles. The recovery rates ranged from 66% to 96% for DBF and from 47% to 96% for DDAC. The different leaching patterns of both preservatives might be reflected by pH of treatment solutions and other factors such as chemical structure, formulation constituents, biological and chemical characteristics of wood, *etc.*, although pH of treatment solutions and wood substrate did not fully account for the differences in the present research.

It has been generally known that heartwood is more durable than sapwood of the same wood species. This is dependent on heartwood extractives (8, 9). Therefore, it is thought that heartwood and sapwood differently act with preservatives, and reaction resultantly causes different levels of retention, distribution and fixation patterns of active ingredients. Wood extractives of two moderately resistant wood species were preliminarily evaluated their termiticidal properties. Filter paper test with extractives of *C. obtusa* showed that termites was started dying soon after the initiation of the test in at 3.55% and 6.64% (m/m) retentions, and then reached 100% mortality after 12th and 8th, respectively. Similarity was seen in the case of *C. japonica* at 3.39 % and 6.51% (m/m) retentions. Wood block test demonstrated that termiticidal efficacy was seen remarkable at retentions of >6 kg/m^3. Impregnation of extractives from *C. japonica* and *C. obtusa* could meet performance requirement designated in JIS K 1571 (7) at the highest retention, 24 kg/m^3. The amount of extractives varied with wood species, and was well correlated with their natural durability (10). The combination of wood extractives and either DBF or DDAC contributed to the enhanced termite resistance in comparison with extracted wood specimens or extracted/DBF or DDAC-treated wood specimens. Wood extractives may provide the preservative-treated wood with an additional protective effect because of their recognizable biocidal characteristics. These results seemed to indicate a possible synergistic or combined effect between heartwood extractives of certain durable wood species and DBF or DDAC against termite attack. Therefore, the lower loadings of wood preservatives would be sufficient for protecting wood from termite attack, when durable heartwood portion is present in the wood substrate to be treated. Decay resistance of extracted wood specimens or extracted/DBF or DDAC-treated wood specimens should be discussed later to generalize these findings.

The current results undoubtedly supported that DBF was applicable to the preservative treatment of various wood species against biological degradation on the basis of the laboratory efficacy comparable to DDAC. DBF favorably outperformed DDAC in the control of microbial coverage on wood and fixation (leaching resistance). Since these are all based on laboratory evaluations, a field trial should be further planned to confirm the performance of DBF as an alternative preservative principally for the impregnation treatment of wood. Other options to widen the use of DBF should be discussed as well, for example, treatment of wood composites such as plywood, particleboard and fiberboard.

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