DEPLETION OF PRESERVATIVES - HISTORY, REALITY AND NEEDS FOR THE FUTURE

by

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Summary

This paper addresses aspects of historical and current developments of the depletion of water-borne wood preservatives from treated wood. Current test methodologies and their suitability in studying various facets of depletion of wood preservatives are reviewed. It is concluded that modifications to existing, and development of new, testing procedures under AWPA standards are desirable in order to allow more realistic evaluation of chemical losses from treated wood in service as it relates to permanence in wood. Current AWPA Standard methods E-11 and E-7 are of value in understanding differences in fixation mechanisms and for the prediction of long term permanence and performance, but are not appropriate for assessing environmental concerns. It is imperative that a range of different test methodologies be established to evaluate various environmental concerns such as aquatic, phytotoxicity, public facility safety, etc, as these pertain to the use of treated wood products in service.

Keywords:
Wood preservation, preservatives, leaching, depletion, AWPA standards, test methodology, CCA, environmental impact.

1. Introduction

During the last decade chemical loss from treated wood in service has gained increasing attention from researchers, governmental regulators, consumers and producers. There are two principal driving forces for this. The first relates to the process of standardizing and setting appropriate chemical retentions for a given new preservative system. In order to be able to predict the long term efficacy for a system prior to the availability of long term performance data from various commodity uses, chemical leaching and depletion information can and should serve as important measures of the preservative system's ability to provide long term service. Second aspect relates to potential losses into the environment of chemical components from wood products treated with preservative systems, when the treated wood is subject to volatilization to air, leaching to water and depletion to soil from wood in service.

In this paper we seek to review historical and current developments relating to chemical loss from wood treated with various water-borne preservative systems, and to put forward our views on the need for appropriate standardized test methodologies which would allow more accurate and/or realistic measurements of the influence of chemical losses on preservative performance and environmental impact.

2. Preservative depletion as an indicator for long term treated product performance

The longevity of treated wood products is dependent on the inherent biocidal effectiveness of the preservative used, and on the permanence of an effective level of the preservative in wood under the conditions to which the treated product is exposed. Until recently the prevailing wisdom was that essentially no chemical losses occurred with fixed waterborne preservatives at all in service once the treated products had left the treatment plant site. This historical belief was based largely on the concept that treated wood in exposed conditions generally provides long service life to the wood, and that such performance would not occur if significant chemical loss occurred. This assumption would hold if preservative retentions used in commercial treatments were close to the toxic threshold necessary for each of the preservative components and that typical biodeterioration hazards are actually encountered in service. However, in most instances commercial preservative retentions are established based on data from laboratory and small sample size field performance trials, and these inherently yield large safety factors compared with actual service material sizes. Furthermore, commodity retentions are usually established with a safety factor over the threshold values, and this leads to a very conservative retention situation for the use of commercial wood products in service. Additionally, it is not uncommon for treating plants to over-treat wood in order to ensure adequate retention and penetration of preservatives into the inner zones of the product.

It is somewhat surprising that there is very limited information available on chemical losses from treated wood in service in contrast to a large number of laboratory studies have been carried out. Studies of chemical components loss from CCA Type C have been reported by Arsenault (1975), Gjovik (1977), Ruddick et al. (1991) and Nurmi (1993) and others. In Arsenault's report, extensive analyses were conducted on marine piles after 18 years' service from between the mud zone to above the water line. The study showed that residual retentions in these assayed zones were very similar to that of the *original targeted (no assay data) retentions* for the treatment and the piles performed well in service, which led the author to conclude that no significant loss of the preservative components had occurred. It could be argued that this study showed only that the retentions in the treated piles were adequate for the exposure conditions used, rather than that no depletion occurred. In contrast, the data generated from another study (Nurmi, 1993) which assayed CCA Type C treated poles after 11 years service showed greater than 40% loss of total CCA active ingredients in both the above ground and ground contact cross sections based on comparison also with the *original targeted (no assay data) retentions*. Lack of original retention assay data before exposure for the piles and the poles from both studies questions the validity of the conflicting conclusions from either. CCA Type C treated jack pine poles were assayed after 1.4 and 9.5 years in service in a Canadian study (Ruddick et al. 1991) and in this case losses of 15.8, 24.2 and 8.2% copper; 0.5, 24.7 and 22.8% chromium; and 15.7, 28.9 and 10.5% arsenic were found in the pole zones 0-10,10-20 and 20-30mm, respectively, between exposures from 1.4 years to 9.5 years. Concerns have been expressed on the sampling of different poles within the same group at the two time periods. Gjovik (1977) sampled pine posts (5-7" in diameter, 30" long) exposed in marine conditions, and these showed a weighted average loss (from the data of 5 zones using 6" diameter to calculate) of 24.9 and 34.0% for copper; 9.8 and 10.1%

for chrome; 11.7 and 11.6% of arsenic after three and eight years' exposure, respectively. While the information from these studies is of value because of the long duration of the tests, the information tends to be inconclusive because critical data such as initial retentions, whole cross-section assays or consistent sampling patterns were often lacking. Such deficiencies in these tests are understandable when one considers that the depletion studies were not envisaged or planned at the time these commodities were installed in the service. This is a problem with much of the existing data and it is important that well designed studies are put in place to avoid this.

In recent years, especially with AWPA standardization activities for new preservatives, renewed efforts have been made to evaluate the permanence of wood preservatives. Most efforts have been through the use of laboratory leaching procedures (AWPA E11) and above ground and ground contact field tests. Typical AWPA E11 laboratory leaching test data and AWPA E7 (with some modifications) field soil depletion data for newly developed systems such as ACQ Type B, ACQ Type D (CSI submissions to AWPA, 1992 & 1994), Copper citrate (Osmose submission to AWPA, 1993), Copper DCD (ISK submission to AWPA, 1993) and Copper Azole (Hickson submission to AWPA, 1994) are listed in Table 1 and 2. Such information on the permanence of the key components in treated wood serves well in developing understanding of the different preservative systems as regards to their fixation mechanisms and long term biological efficacy as provided by individual components. The information also can provide guidance on whether or not proposed preservative systems and/or retention levels are acceptable for the applications under consideration. There is no doubt that these methods are very useful for providing comparisons of chemical losses with different preservative systems and components under the same test conditions and same material size. Questions remain whether these test conditions and exposures are adequate or appropriate for the determination of chemical loss for treated commodities used in commercial applications.

While little field depletion data exists for currently used preservatives, most of that which is available has focused on vertical wood samples in ground contact. Analysis of both above ground and ground contact portions of such samples has been used to estimate chemical losses for above ground and ground contact applications. The suitability of using above ground data generated from vertical samples connected with the in-ground portion of the same sample to represent above ground applications in general, and especially for horizontal decking applications is questionable. Lumber exposed horizontally above ground can be subjected to greater wetting and drying cycles than is the case for the above ground portion of vertical poles or posts. The chemical depletion pattern observed with these different exposure configurations shows considerable variability which needs further scientific study and test method development.

The relationship between retention and relative depletion has also been largely ignored. The trends seen in our studies with CCA Type C treated wood in both laboratory leaching and field exposures (Table 3 and 4) show that percentage chemical component losses are inversely proportional to treatment retentions. This clearly shows that single retention leaching and depletion tests may be poor indicators and predictors of preservative depletion in service. Considerable data can be provided by the use of multiple retention leaching and depletion studies, and information so generated can be indicative of optimum retention ranges for different preservatives.

Within the AWPA standards, the test methods AWPA E-11 and AWPA E-7 both partially address chemical leaching and soil depletion aspects, respectively. No standard test methods for above ground applications exist in spite of the overwhelming use of treated lumber in above ground situations. In order to be able to predict preservative permanence under more realistic conditions, the establishment of standardized procedures reflecting above ground, ground contact, and marine applications can no longer be ignored. Issues such as sample size, number of replicates used, multiple retention levels, initial retaining samples, soil characteristics as well as testing climate conditions have to be addressed.

3. Assessment of potential interaction of preservative depletion with environment

In spite of the long held notion to the contrary, the reality is that wood preservatives deplete from treated products to a measurable extent. However, this depletion of preservative components into the environment may engender little if any real impact on the environment when the key factors such as rate of loss and dilution in the environment are considered. The environmental issue must be addressed, however, in order that such concepts can be met head-on with scientific data that demonstrates how much chemical is lost from treated commodities in service, the time period of such losses, effects, if any, of such losses on the environment. This applies to particular to applications which have raised concerns, such as the use of treated wood in aquatic environments, children's playgrounds, gardening applications and possible soil contamination situations.

Current standardized testing procedures were designed to maximize chemical losses using very small sample size materials which provide a large exposed wood surface area to wood mass. The data generated by these methods represent overall or possibly maximum life time percentage losses of the chemicals being tested. As discussed above, while these data provide information on the long term performance of preservative systems, directly using these findings to extrapolate and predict chemical losses from full size commodities used in a given environment at a given time may be grossly overestimated. This could lead to unnecessary concerns regarding the potential for environmental contamination and provide inaccurate information to consumer opinion regarding the use of treated wood products. It is imperative for our industry to establish a range of standardized scientific test methodologies and to generate the data necessary to identify the problems and solutions, which would both educate the public and provide reliable data to governmental regulators.

Recent studies by Brooks (1994, 1995a&b) on the assessment of the environmental risks associated with the use of CCA and ACZA treated wood products in aquatic environments may serve as a model for such testing methodology development. From these reports, the assessment methodologies can be summarized as follows:

a) To determine leachability of a preservative system, commodity/semi-commodity size treated materials with a defined wood surface area to the volume of water are used. Temperature, pH and salinity are considered based on the application under consideration. Leaching results are generated in terms of ug/cm^2 of wood surface in the leachate with the leaching rate determined after no further leaching occurs.

b) Criteria used should relate to the allowable limits for the elements to be tested in a given environment at given conditions. For example, in the case of copper, limits would include the freshwater chronic copper standard; the maximum marine sediment impact zone copper standard and the marine water copper standard, etc.

c) Establishment of computer models which include the parameters associated with the exposure conditions, such as standard limits, dimension/surface area of wood structure under consideration, current velocity and other related characteristics.

d) Final analysis is carried out using a combination of model outcome with treated wood retention, leaching rate and quantity in ug/cm^2, which allows the prediction of aquatic risks.

As an example of the application of such a process, one study such study (Brooks 1995b) established that the minimum flow rate required for the current surrounding ACZA and CCA treated bulkheads should be 18.5 and 3.5 cm sec^{-1}, respectively, on day one of the installation in order to meet the Washington State Water Quality Standards in the Columbia River. Also, the recommendations of the time required to meet Washington State copper water quality criteria next to newly installed ACZA and CCA treated bulkheads as a function of current speed were made (Table 5).

Similarly, the assessment of the unfixed surface chemical of the treated wood on playground equipment uses has been reported (US Consumer Product Safety Commission report, 1990) and a method of cloth wiping to determine chemical contaminations was used. The questions of sampling size and whether wetting procedures should be included during the sampling have been raised from this type of approach. Other attempts to examine the influence of the chemical from the treated wood relating to gardening and plant growth also have been reported (Qvarnstrom, 1982, Speir et al., 1992 a&b, Jin and Preston 1993 a&b). The issue of soil contamination (Nurmi 1993, Suzuki and Sonobe 1993) and chemical movement/biodegradability in soil has also gained increased attention recently.

The above mentioned studies and other available reports have laid a good foundation for the development of various environmental assessment methodologies. To date, no standardized test methodologies have been established to assess all these concerns by standards setting bodies such as AWPA, ASTM or CSA, who have interests in the wood preservation industry. This void in the availability of appropriate tools and data for evaluating environment issues constitutes an opportunity for misuse or incorrect interpretation of the depletion data generated with methods which were not designed for the examination of environmental effects of treated wood in service. It is timely for our industry to work together, to face both the positive and the negative realities and to build a scientifically substantiated data base for the preservative products being used and those being developed, in regard to their potential environmental impact.

4. Conclusions

Treated wood products are facing strong competition from alternative materials such as steel and plastic composites. These products are gaining ground from perceptions relating to lower natural resource consumption and lower environmental impact than in the case for wood products treated with apparently toxic chemicals. It is imperative that our industry provide comprehensive scientific evidence to demonstrate the merits and environmental safety of treated wood products used according to industry standards and specifications. Only by doing so can treated wood products in compete successfully with alternative materials, not only on the questions of durability and strength properties, but also in regard to environmental issues. To do so, we have to develop appropriate test methodologies.

It is our belief that existing test methodologies such as AWPA E-11 and AWPA E-7 partially address chemical leaching and soil depletion aspects and can provide comparisons of chemical losses with different preservative systems and components under the same test conditions and same material size and information on chemical losses for the prediction of long term performance. In order to be able to predict preservative permanence under more realistic conditions, action must be taken to review and establish standard procedures reflecting above ground, ground contact, and marine applications. Issues such as sample size and configuration, number of replicates used, multiple retention levels, initial retained samples, soil characteristics as well as testing climate conditions have to be addressed.

On the other hand, such methodologies are neither designed for nor appropriate for use in the assessment of environment impact. A range of test methodologies to evaluate treated wood products in service in regards to environmental concerns such as aquatic toxicity, phytotoxicity, public facility safety, etc, need to be established. In such methods, factors such as the rate of chemical loss, mobility and biodegradability of the chemicals, and the surrounding natural conditions, such as rainfall quantity, water flow rate, soil characteristics, and plant, animal or marine/fresh water species must be included.

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Table 1. Chemical components leached using AWPA E11 testing procedures

Preservative Type	Cu %	Co-Biocides %
ACQ Type B[1]	14.7	3.3 DDAC
ACQ Type D[2]	9.6	4.0 DDAC
Copper Citrate[3]	26.0	N/A for citrate
CuAz Type A[4]	7.9	9.1 Azole 100 Boron

1 & 2: Data from CSI submissions to AWPA, 1992 and 1994 respectively.
3: Data from Osmose submission to AWPA 1993.
4: Data from Hickson submission to AWPA 1994.

Table 2. Chemical components depleted from soil using AWPA E7 testing procedures

Preservative Type	Cu %	Co-Biocides %
ACQ Type B[1]	19.0	42.0 DDAC
ACQ Type D[2]	21.6	31.7 DDAC
Copper Citrate[3]	28.3	93.2 Citrate
CuAz Type A[4]	12.2	31.6 Azole 99.9 Boron
CuDCD[5]	27.7	4.5 SDDC

1 & 2: Data from CSI submissions to AWPA, 1992 and 1994 respectively.
3: Data from Osmose submission to AWPA, 1993.
4: Data from Hickson submission to AWPA, 1994.
5: Data from ISK Biotech Corporation submission to AWPA, 1993.

Table 3. Chemical components leached from CCA treatment Vs retentions using AWPA E11 testing procedures

Retention	%Chemical loss		
kg/m^3	Cu	As	Cr
1.0	11.0	87.0	10.9
2.0	3.3	35.8	3.3
4.0	2.6	17.7	0.8
6.4	2.4	9.5	0.4
9.6	0.8	4.7	0.2

Table 4. Chemical components leached from CCA treatment Vs retentions from an above ground test

Retention	%Chemical loss		
kg/m^3	Cu	As	Cr
1.0	27.0	72.8	23.6
2.0	13.1	40.1	17.8
4.0	7.8	18.8	13.6

Table 5. Flow rate requirements for Installation of ACZA and CCA treated bulkheads in the Columbia River (Brooks, 1995b).

Flow rate (cm/sec)	ACZA (minimum days)	CCA (minimum days)
1.0	15	52
3.5 (minimum)		The first day
5.0	7	
10.0	3	
18.5 (minimum)	The first day	