

**Alternatives to Chromated Copper Arsenate (CCA)
for Residential Construction**

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Prepared for Proceedings of the
Environmental Impacts of Preservative-Treated Wood Conference
Orlando, Florida

February 8–10, 2004

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ABSTRACT

For decades chromated copper arsenate (CCA) was the primary preservative for treated wood used in residential construction. However, recent label changes submitted by CCA registrants will withdraw CCA from most residential applications. This action has increased interest in arsenic-free preservative systems that have been standardized by the American Wood Preservers' Association. These include acid copper chromate (ACC), alkaline copper quat (ACQ), copper azole (CBA-A and CA-B), copper citrate (CC), copper dimethyldithiocarbamate (CDDC), and copper HDO (CX-A). All of these CCA alternatives rely on copper as their primary biocide, although some have co-biocides to help prevent attack by copper-tolerant fungi. They have appearance and handling properties similar to CCA and are likely to be readily accepted by consumers. Prior studies indicate that these CCA alternatives release preservative components into the environment at a rate greater than or equal to that of CCA, but because these components have lower mammalian toxicity they are less likely to cause concern in residential applications. As the treated wood industry evolves it is probable that a wider range of types and retentions of wood preservatives will become available, with the treatment more closely tailored to a specific type of construction application.

Keywords: Chromated copper arsenate (CCA), alternative preservatives, leaching, environmental concerns

INTRODUCTION

Because it is biodegradable, wood used in applications where it may be attacked by decay fungi or insects should be protected by pressure treatment with wood preservatives. Wood preservatives are broadly classified as either water- or oil-based, depending on the chemical composition of the preservative and the carrier used during the treating process. The oil-type preservatives creosote, pentachlorophenol, and copper naphthenate are commonly used for applications such as posts, poles, piles, and glue-laminated beams. They are not usually used for applications that involve frequent contact with human skin or inside dwellings because they may be visually oily, oily to touch, or have a strong odor. Water-based preservatives have become more widely used in recent years because the treated wood has a dry, paintable surface and no odor. The most common of these preservatives has been chromated copper arsenate (CCA). Wood treated with CCA, commonly called "green treated" wood, dominated the residential market for several decades and was sold at lumberyards under a variety of trade names. However, as a result of voluntary label changes submitted to the Environmental Protec-

tion Agency (EPA) by the CCA registrants, the EPA labeling of CCA will limit the use of the product primarily to industrial applications. The label change is effective December 31, 2003, although suppliers will be allowed to sell existing stocks of CCA-treated wood after that date. It is important to note that the recent action does not affect end-uses of wood treated before December 31, 2003, or any existing structures.

APPLICATIONS AFFECTED BY CCA LABEL CHANGES

The label changes cite specific commodity standards listed in the 2001 edition of the American Wood Preservers' Association (AWPA) standards [1]. The changes were made as part of the ongoing CCA re-registration process and in light of current and anticipated market demand for alternative preservatives for non-industrial uses. Most applications of sawn lumber and timbers are affected, although CCA will still be allowed for treatment of roundstock (poles, building posts, and piles). However, there are exceptions that allow use of CCA for some sawn products. Examples of sawn products that still may be treated with CCA include the following:

- Lumber in permanent wood foundations (Fig. 1)
- Sawn structural piles used to support residential and commercial structures
- Sawn building poles and posts used in agricultural construction
- Wood used in highway construction, including lumber and timbers
- Utility pole crossarms
- Wood of all dimensions used in salt water and subject to marine borer attack

Treatment of engineered wood products, such as glued-laminated beams and timbers, structural composite lumber, and plywood will also be allowed in most applications. Overall, the label changes are expected to result in a 70% to 80% reduction in the volume of CCA-treated wood. This raises the question, What preservatives will be used to replace CCA and what are the characteristics of these alternatives?

CHALLENGES IN DEVELOPING NEW WOOD PRESERVATIVES

In today's society we have become accustomed to rapidly developing and changing products in most residential commodities. Consumers and regulators sometimes seem frustrated that the wood preservation community does not rapidly produce a wide selection of effective replacements for CCA. Unfortunately, it currently takes many years to bring a new wood preservative to market. A formulation must meet several important criteria to be an effective wood preservative. The first challenge is identification of a combination of active ingredients that will provide long-term protection against a wide range of organisms that damage wood. In addition to decay fungi, the preservative



Figure 1 CCA is still registered for some residential applications, such as permanent wood foundations.

must protect against attack by termites, carpenter ants, beetles, and other insects. Even within decay fungi there is a range of species and strains that differ in chemical tolerance. The preservative must also resist detoxification by non-wood-attacking fungi and bacteria. These requirements preclude the use of compounds that have a very narrow or specific toxicity to only one type of organism. A wood preservative needs some degree of broad spectrum efficacy, which is in direct conflict with the goal of identifying environmentally friendly compounds.



Figure 2 Wood preservative formulations undergo rigorous testing, including lengthy field trials.

Because a wood preservative must protect against a range of organisms while simultaneously resisting environmental degradation, it has proven difficult to develop reliable methods of accelerating evaluation of preservatives. Typically, at least 3 to 5 years of test stake exposure in multiple locations is needed to demonstrate the potential for long-term efficacy in ground-contact applications (Fig. 2). In addition, a battery of tests, including laboratory fungal and leaching evaluations, corrosion tests, and mechanical property evaluations, are needed to obtain a listing of a

preservative formulation within the AWWA Book of Standards. AWWA members, who represent government agencies, universities, and chemical suppliers, review the results of these tests. The data must then be supplemented with commercial treatment trials to demonstrate that the formulation can be effectively and practically applied to wood products.

This efficacy testing and evaluation is independent of that needed to obtain EPA registration of a new pesticide product. Registration of a new biocidal active component may require several years and millions of dollars to complete. Because of the high cost of EPA registration of new compounds, there is a strong tendency to use compounds that have already been registered for other applications.

As a result of all these factors, it is difficult to develop new preservatives and bring them quickly to market. The wood treatment industry cannot immediately respond to changing regulatory or societal expectations, but instead must attempt to anticipate and plan for future changes.

ALTERNATIVES TO CCA PRESERVATIVE TREATMENT

Preservative manufacturers have been working for years to develop arsenic-free alternatives. The AWWA has standardized several arsenic-free preservative formulations, although not all are available commercially. All of these alternatives rely on copper as their primary active ingredient because copper is an excellent fungicide, is relatively inexpensive, and has relatively low mammalian toxicity. These preservatives are discussed in alphabetical order in the following text.

Acid Copper Chromate

Acid copper chromate (ACC) has been used sporadically as a wood preservative in Europe and the United States since the 1920s. In the last few decades, it has been primarily used for the treatment of wood used in cooling towers. ACC contains 31.8% copper oxide and 68.2% chromium trioxide (Table 1). The treated wood has a light greenish-brown color and little noticeable odor. Tests on stakes and posts exposed to decay and termite attack indicate that ACC provides acceptable average service life, but that wood used in ground contact may suffer occasional early failure from attack by copper-tolerant fungi [2]. ACC is listed in AWWA standards for treatment of a wide range of softwood and hardwood species used above ground or in ground contact. However, in critical structural applications such as highway construction, its AWWA listings are limited to sign posts, handrails and guardrails, and glue-laminated beams used above ground. It may be difficult to obtain adequate penetration of ACC in some of the more refractory wood species such as white oak or Douglas-fir. This is because ACC must be used at relatively low treating temperatures (38°C to 66°C, 100°F to 150°F), and because rapid reactions of chromium in the wood can hinder further penetration during the longer pressure periods needed for refractory species. The high chromium content of ACC, however, has the benefit of preventing much of the corrosion that might otherwise occur with an acidic copper

Table 1 Preservative Formulations Standardized for Applications Typical of Residential Construction

Preservative formulation as listed in AWP standards	Proportion of preservative component		Retention kg/m ³ (lb/ft ³)	
			Above ground	Ground contact
Acid copper chromate (ACC)	32% CuO	68% CrO ₃	4.0 (0.25)	6.4 (0.40)
Alkaline copper quat (ACQ-B, D)	67% CuO	33% DDAC ^a	4.0 (0.25)	6.4 (0.40)
Alkaline copper quat (ACQ-C)	67% CuO	33% BAC ^b	4.0 (0.25)	6.4 (0.40)
Copper azole (CA-B)	96% Cu	4% Azole ^c	1.7 (0.10)	3.3 (0.21)
Copper azole (CBA-A)	49% Cu	2% Azole ^c 49% H ₃ BO ₃	3.3 (0.20)	6.5 (0.41)
Copper citrate (CC)	62% CuO	38% citric acid	4.0 (0.25)	6.4 (0.40)
Copper bis dimethyldithiocarbamate (CDDC)	17%–29% CuO	71%–83% SDDC ^d	1.6 (0.10)	3.2 (0.20)
Copper HDO (CX-A) (pending EPA registration)	61.5% CuO	14% CuHDO ^e 24.5% H ₃ BO ₃	2.4 (0.15)	NA ^f

^a Didecyldimethylammoniumchloride; ^b Alkylbenzyltrimethylammoniumchloride; ^c Tebuconazole

^d Sodium dimethyldithiocarbamate; ^e Bis-(N-cyclohexyldiazeniumdioxy)copper; ^f Not in standards as yet.

preservative. As of the writing of this report, ACC does not have an EPA label and its future availability is unclear.

Alkaline Copper Quat

Alkaline copper quat (ACQ) is one of several wood preservatives that has been developed in recent years as an alternative to CCA. It has been commercially available in some parts of the United States for several years (Fig. 3). The active ingredients in ACQ are copper oxide (67%) and a quaternary ammonium compound (quat). Multiple variations of ACQ have been standardized or are in the process of standardization. ACQ type B (ACQ-B) is an ammoniacal copper formulation, ACQ type D (ACQ-D) an amine copper formulation, and ACQ type C (ACQ-C) a combined ammoniacal–amine formulation with a slightly different quat compound. ACQ-B treated wood has a dark greenish-brown color that fades to a lighter brown and may have a slight ammonia odor until the wood dries. Wood treated with ACQ-D has a lighter brown color and little noticeable odor, while the appearance of wood treated with ACQ-C varies between that of wood treated with ACQ-B or ACQ-D, depending on the formulation. The ACQ formulations are listed in AWP standards for a range of applications and many softwood species, although the listings for ACQ-C are limited because it is the most recently standardized formulation. Minimum retentions of ACQ formulations are specified for wood used

above ground and in ground contact (Table 1). The multiple formulations of ACQ allow some flexibility in achieving compatibility with a specific wood species and application. When ammonia is used as the carrier, ACQ has improved ability to penetrate into difficult-to-treat wood species. However, in wood species that can be readily treated, such as Southern Pine, an amine carrier can be used to provide a more uniform surface appearance.



Figure 3 ACQ-treated wood has been available commercially for several years in some areas of the United States.



Figure 4 Lumber treated with copper citrate (CC).

Ammoniacal Copper Citrate

Ammoniacal copper citrate (CC) is a recently developed wood preservative that utilizes copper oxide as the fungicide and insecticide and citric acid to aid in the distribution of copper within the wood structure. The color of the treated wood varies from light green to dark brown (Fig. 4). The wood may have a slight ammonia odor until it is thoroughly dried after treatment. Exposure tests with stakes and posts placed in ground contact indicate that the treated wood resists attack by both fungi and insects. However, it appears that the

lack of a co-biocide may render wood used in ground contact vulnerable to attack by certain species of copper-tolerant fungi [3]. CC is listed in AWP standards for treatment of a range of softwood species and wood products for wood used above ground or in ground contact. CC is not listed in AWP standards for use in highway construction or other structurally critical applications. As with other preservatives containing ammonia, CC has an increased ability to penetrate into difficult-to-treat wood species such as Douglas-fir. At the time of publication of this report, CC had only limited commercial availability.

Copper Azole

Copper azole is another recently developed preservative formulation that relies primarily on amine copper, but with co-biocides, to protect wood from decay and insect attack. The first copper azole formulation developed was copper azole Type A (CBA-A), which contains 49% copper, 49% boric acid, and 2% Tebuconazole (Fig. 5). More recently, the copper azole Type B (CA-B) formulation was standardized. CA-B does not contain boric acid and is comprised of 96% copper and 4% Tebuconazole. Wood treated with either copper azole formulation has a greenish-brown color and little or no odor. The formulations are listed in AWP standards for treatment of a range of softwood species used above ground or in ground contact. Although listed as an amine formulation, copper azole may also be formulated with an amine–ammonia solvent. The ammonia may be included when the copper azole formulations are used to treat refractory species, and the ability of such a formulation to adequately treat Douglas-fir has been demonstrated. The inclusion of ammonia, however, is likely to have slight effects on the surface appearance and initial odor of the treated wood.

Copper Dimethyldithio-Carbamate

Copper dimethyldithio-carbamate (CDDC) is a reaction product formed within the wood after treatment with two different treating solutions. It contains copper and sulfur compounds. CDDC is standardized for treatment of Southern Pine and some other pine species at copper retentions of 1.6 kg/m^3 (0.1 lb/ft^3) or 3.2 kg/m^3 (0.2 lb/ft^3) for wood used above ground or in ground contact, respectively. CDDC-treated wood has a light brown color and little or no odor. At the time of this publication, CDDC treated wood was not commercially available.



Figure 5 CCA-treated supports and CBA-A treated decking.

minimum retention of copper HDO for above-ground use is 2.4 kg/m^3 (0.15 lb/ft^3). At the time of this publication, EPA registration of CX-A was pending.

Copper HDO (CX-A)

Copper HDO is an amine copper based preservative that has been used in Europe and recently standardized by the AWPA. The active ingredients are copper oxide, boric acid, and copper-HDO (Bis-(N-cyclohexyl-diazeniumdioxo copper). The appearance and handling characteristics of wood treated with CX-A are similar to those of other copper-based treatments. CX-A formulations have been evaluated in a range of exposures, but at this time have only been standardized for uses above ground. The

Borates

Borate-treated wood should be used only in applications where the wood is kept free from rain-water, standing water, and ground contact. Borate preservatives are sodium salts such as sodium octaborate, sodium tetraborate, and sodium pentaborate that are dissolved in water. These formulations have received increased attention in recent years because they are inexpensive and have low mammalian toxicity. Borate-treated wood is also odorless and colorless, and it may be painted or stained. Borates are effective preservatives against decay fungi and insects. Borate preservatives are diffusible, and, with appropriate treating practices, they can achieve excellent penetration in species that are difficult to treat with other preservatives. However, the borate in the wood remains water soluble and readily leaches out in soil or rainwater. Borate preservatives are standardized by the AWPA, but only for applications that are not exposed to liquid water. An example of such a use is in the construction of wooden buildings in areas of high termite hazard.

Practical Differences Between CCA Alternatives

From a practical, end-use basis, the consumer will notice little difference between CCA and the recently developed alternatives. Most residential consumers of treated wood will probably not even be aware that CCA has been replaced because all types of treated wood are referred to as “green-treated” wood. The appearance, strength properties, and handling characteristics are very similar to those of CCA. CCA alternatives are slightly more expensive, however, with the treated wood costing from 10% to 30% more than CCA-treated wood. With the possible exception of ACC, the alternatives also tend to be somewhat more corrosive to metal fasteners than is CCA. Hot-dipped galvanized or stainless steel fasteners should be used when building with wood treated with CCA alternatives.

ENVIRONMENTAL CONCERNS WITH CCA ALTERNATIVES

Environmental and health concerns have been raised over the use of CCA-treated wood. It is likely that CCA alternatives will circumvent some of these concerns simply because they do not contain arsenic. Because they have been developed relatively recently and/or have been used infrequently, only limited research has been conducted on their potential leaching and environmental impact. Much available data have been obtained using small samples that accelerate leaching and allow more rapid comparisons between preservative formulations. Although useful as a comparative tool,



Figure 6 Evaluation of ACQ-B treated wetland boardwalk for leaching and environmental impact.

leaching rates derived from small samples should not be directly extrapolated to commodity size material.

The release and environmental impact of copper from ACQ-B treated wood was recently evaluated in a wetland boardwalk study (Fig. 6) [4]. Elevated levels of copper were detected in rainwater, soil, and sediments collected adjacent to the treated wood. The rainwater collection indicated that release of copper peaked by 6 months after construction, reaching average release rates of 35 ug per cm^2/inch of rain. Much lower average release rates (approximately 5 $\text{ug}/\text{cm}^2/\text{inch}$ of rain) were observed by 11.5 months after construction.

The relatively high release of copper during the first 6 months of the study was reflected in the concentrations of copper detected in the soil; geometric mean soil concentrations were elevated by approximately 373 ppm directly under the edge of the boardwalk. However, the copper accumulations were localized in soil very close to the boardwalk; the geometric mean concentration was elevated by only 16 ppm 60 cm (24 inches) away from the boardwalk. Sediment copper concentrations also appeared to peak at about 6 months, when the geometric mean of samples removed from directly under the edge of the boardwalk reached 113 ppm, an elevation of approximately 92 ppm over background levels. Copper mobility was greater in the sediment than in the soil, causing slight elevations in three samples removed 300 cm (10 ft) away from the boardwalk 11.5 months after construction. This study can truly be considered a “worst case” scenario, since the boardwalk decking was over-treated and inadequately conditioned [4]; smaller releases might be expected from material treated to a retention more appropriate for this application. Despite the accumulations of copper detected in the environment, no significant impact was detected on the quantity or diversity of aquatic insects at the site [4].

Other studies of leaching from ACQ-treated wood have been conducted with small specimens intended to exaggerate leaching and accelerate comparisons. Copper leaching from ACQ-B and CCA was compared in a soil-bed test with 19- by 8- by 200-mm (0.75- by 0.30- by 7.9-inch) stakes [5]. After 9 months, copper loss from stakes treated to 9.6 kg/m^3 (0.6 lb/ft^3) averaged 19% from ACQ-B and 18% from CCA. The ACQ-treated stakes also lost 30% of their DDAC, while the CCA-treated stakes lost 11% chromium trioxide and 16% arsenic pentoxide during the test. In a subsequent soil-bed test, leaching of ACQ-B and ACQ-D was compared in Southern Pine stakes (6 by 19 by 203 mm, 0.25 by 0.75 by 8 inches) that had been treated to 6.4 kg/m^3 (0.4 lb/ft^3) retention [6]. After 3 months, the ACQ-D stakes had lost 15.4% CuO and 12.9% DDAC, and ACQ-B stakes had lost 17.4% CuO and 32.7% DDAC [6]. ACQ-B and CCA leaching data were also collected from 44-month ground-contact depletion tests conducted in Hilo, Hawaii, using 19- by 19- by 1,000-mm (0.75- by 0.75- by 39-inch) stakes treated to 6.4 kg/m^3 (0.4 lb/ft^3) retention [5]. Averaging losses from the top, bottom, and middle of the stakes revealed that 21% copper oxide, 9% chromium trioxide, and 22% arsenic pentoxide were lost from CCA-treated stakes and 19% copper oxide and 42% DDAC were lost from the ACQ-B treated stakes. A subsequent study with similar size CCA-C treated stakes reported only 5% loss of arsenic pentoxide after 5 years of exposure in Florida [7]. It is evident that these tests presented severe leaching conditions because of the small stake size and the extreme conditions, and the leaching rates should not be extrapolated to commodity size material.

Above-ground depletion tests were conducted in Hawaii on 51- by 19- by 356-mm (2.0- by 0.75- by 14.0-inch) CCA- and ACQ-B-treated Southern Pine samples [5]. After 12 months, copper oxide losses from stakes treated to 4 kg/m^3 (0.25 lb/ft^3) were 14% from ACQ-B and 8% from CCA. Twenty-seven percent of the DDAC was lost from the ACQ-treated stakes, and 14% chromium trioxide and 19% arsenic pentoxide were lost from the CCA-treated stakes. A similar test was conducted

with samples treated with ACQ-D and CCA-C. After 6 months, the ACQ-D samples treated to 4 kg/m^3 (0.25 lb/ft^3) had lost approximately 10% copper oxide and 32% DDAC, and the CCA-C treated samples had lost 9% copper oxide [6].

In a study that provides insight into leaching rates of treated wood exposed above ground under in-service conditions, depletion tests were conducted on decks built with 38- by 140-mm (1.5- by 5.5-inch) lumber that had been treated with CCA-C, ACQ-B, or copper boron (Cu:BAE = 25:25) with formulation characteristics similar to those of CBA-A [8]. The boards were treated with either full cell or empty cell processes to a retention of 4 kg/m^3 (0.25 lb/ft^3) copper for the copper boron or to 6.4 kg/m^3 (0.4 lb/ft^3) (total retention) with either ACQ-B or CCA-C. During 20 months in Conley, Georgia, the decks were exposed to more than 2 m (80 inches) of rainfall, which was periodically collected and analyzed for copper and boron. The copper–boron decks leached 8% to 12% copper and 55% to 65% boric acid, the ACQ-B decks lost 8% to 10% copper, and the CCA-treated decks lost 5% copper. This loss corresponded to leaching rates of approximately $1,722$ and $1,184 \text{ } \mu\text{g/cm}^2$ (0.0035 and 0.0024 lb/ft^2) for copper from the copper–boron treated material, $1,292$ and $969 \text{ } \mu\text{g/cm}^2$ (0.0026 and 0.0020 lb/ft^2) for the ACQ-B treated material, and 215 and 161 g/m^2 (0.0004 and 0.0003 lb/ft^2) for the CCA-treated material for modified full-cell and full-cell treatments, respectively. With both types of treating schedules, copper loss from the copper–boron treated wood was greatest during the first 508 mm (20 inches) of rainfall and minimal during the last 254 mm (10 inches) of rainfall.

A 5-year study of copper loss from 178- to 229-mm- (7- to 9-inch-) diameter Southern Pine pole stubs that had been treated with copper citrate to a target retention of 9.6 kg/m^3 (0.6 lb/ft^3) was conducted in Gainesville, Florida [9]. The researchers removed increment cores from 152 mm (6 inches) below ground, at groundline, and 610 mm (24 inches) above ground before exposure and 12, 24, 36, 48, and 60 months after exposure. Leaching data were variable between sampling periods, but copper losses of approximately 50%, 10%, and 39% were noted for the 0 to 13, 13 to 25, and 25 to 52 mm (0 to 0.5, 0.5 to 1, and 1 to 2 inch) assay zones, respectively, in the below-ground zone after 5 years. The authors estimate a total copper loss of approximately 28% from the below-ground zone during the first year, with minimal losses in subsequent years.

Also pertinent to the leaching of boron and copper from ammoniacal formulations is a study evaluating leaching from 38- by 89-mm (1.5- by 3.5-inch) stakes treated with ammoniacal copper borate and exposed for 11 years at a test site in Mississippi [10]. The original copper oxide retention in the stakes varied from 0.29% to 1.98%, and the boric acid content varied from 0.10% to 0.71%. During exposure, 95% to more than 99% of the boron leached from the groundline portion of the stakes and 78% to 93% of the boron was lost from the aboveground portion of the stakes. Copper losses varied from 3% to 33% in the groundline portion of the stakes and 0 to 28% in the aboveground portion. With both copper and boron, the greatest percentage of loss occurred at the lower retention levels. Because of the relatively large dimensions of the stakes used in this study, the leaching rates noted for ammoniacal copper may be more representative of losses in service than are stake test data reported previously for other ammoniacal formulations.

The release and environmental accumulation of copper from CDDC-treated wood was recently evaluated in a wetland boardwalk study [4] (Fig. 7). During the first three post-construction inspections, copper concentrations immediately adjacent to the boardwalk slowly increased; 5.5 months after construction, the average copper level in the top 15 cm (5.9 inches) of soil was only 28 ppm higher than the average pre-construction level. This trend changed at the 11-month inspection, when the combination of sand applied to the walkway and heavy rainfall increased geometric mean soil copper levels immediately adjacent to the boardwalk to a level approximately 135 ppm higher than pre-construction levels. It is likely that much of the increase in soil copper levels during this period was due to removal of wood particles by abrasion, and that levels would have been lower if sand had not been applied to the boardwalk. However, one can conclude that sand should not be applied to CDDC-treated wood (or probably other types of treated wood) when it is used in areas where release of copper into the environment is a concern.



Figure 7 This CDDC-treated boardwalk is being evaluated for leaching and environmental accumulation of copper.

457-mm (0.75- by 0.75- by 18-inch) Southern Pine stakes exposed in Bainbridge, Georgia [11]. The stakes were treated to either 9.6 kg/m^3 (0.6 lb/ft^3) with CCA or to 3.5 kg/m^3 (0.22 lb/ft^3) (as copper) with a CDDC formulation in which copper sulfate was the copper source. Copper retention levels in the above- and below-ground portions of the stakes were compared to estimate preservative leaching. The CDDC-treated stakes had 77% less copper below than above ground, and the CCA-C treated stakes had 72% less copper below than above ground. Actual copper losses may have been greater because some leaching did occur above ground. These leaching rates may sound extreme, but it is important to remember the length of the test and that small-sized stakes lose a much greater percentage of their preservative than does product-sized material.

Little information is available on the rate of leaching from ACC-treated wood. One study compared the depletion of ACC and an older formulation of CCA (CCA-A) from several softwood species of cooling tower slats [12]. After 10 years, the average depletion from the ACC-treated slats was approximately 35%, while that from the CCA-A treated slats was 25%. The unusual dimensions of the slats (10-mm by 32-mm by 182-cm, 0.375- by 1.25- by 71.5 inches) and the unique exposure environment make it difficult to compare the leaching results to other applications. However, the results do suggest that the rate of depletion from ACC-treated wood is comparable to or slightly greater than that from CCA-A treated wood. The ACC treatment solution does utilize hexavalent chromium, but the chromium is converted to the more benign trivalent state during treatment and subsequent storage of the wood. ACC treatment solutions contain a higher proportion of hexavalent chromium than do CCA solutions, and recent research indicates that a longer reaction period is needed for ACC [13].

The literature indicates that all the CCA alternatives will release copper into the environment at a rate greater than or equal to that of CCA. This is not surprising because all of the recently standardized CCA alternatives contain several times as much copper (proportionally) as does CCA. Fortunately, copper is associated with fewer mammalian health concerns than is arsenic. Environmental release of co-biocides such as boron or quaternary ammonium compounds is also to be expected, but these co-biocides also have relatively low mammalian toxicity. The CCA alternatives may not offer significant advantages over CCA in aquatic applications or other applications where copper release might be a concern. From this perspective, the recent label changes on allowable uses of CCA are logical. CCA will still be allowed for most aquatic uses, while the arsenic-free alternatives will be used where human exposure is greatest.

Leaching from wood treated with water-based preservatives is also dependent on completion of fixation reactions. The active ingredients of various waterborne wood preservatives (copper, chromium, arsenic, and/or zinc) are initially water-soluble in the treating solution but become resistant to leaching when placed into the wood. This leaching resistance is a result of the chemical “fixation”

It is notable that soil movement of the copper was apparently quite limited; during the course of the study, only a few of the samples removed 15 cm (6 inches) away from the boardwalk contained elevated levels of copper, and the maximum copper concentration detected at greater distances from the wood was 37 ppm. Copper movement downward in the soil was also quite limited; the vast majority of copper leached was confined within the top 15 cm (6 inches) of soil. Thus, it appears that any environmental contamination is restricted to immediately adjacent to the wood when CDDC-treated wood is used in or over soil.

Long-term (23 years) leaching data were reported for CDDC for 19- by 19- by



Figure 8 Stacks of ACQ-C and CA-B treated lumber await sale at a lumberyard. Multiple retentions are available for different end-uses.

have led Canada and European countries to develop standards or guidelines for “fixing” treating wood. The AWWA has recently formed several task forces to consider the development of fixation or “leaching minimization” standards for CCA-C and other wood preservatives, but there are not yet nationally recognized standards for fixation of waterborne preservatives in the United States. In addition, an on-going effort is underway to develop Best Management Practice (BMP) type standards to ensure that treated wood is produced in a way that will minimize environmental and handling concerns. The Western Wood Preservers Institute (WWPI) has developed guidelines for treated wood used in aquatic environments [14], and the AWWA has active task forces working to develop guidelines for waterborne preservatives. As BMP-type standards are developed, it will be important to include them in specifications of treated wood products.

As researchers continue to respond to environmental concerns, further progress will be made in reducing environmental impacts from preservative treated wood. Current preservatives are used in a broad range of applications, ranging from mild to very severe deterioration hazards. Because of this, the amount or type of chemical used is stronger than necessary for many applications. Future preservative treatments may be more closely aligned with certain types of applications, allowing use of less toxic chemicals in many applications. In addition, greater emphasis will be placed on using the minimum amount of preservative needed to protect the wood. This stratification has already begun, as some manufacturers are offering decking treated to a lower retention than are the stringers, which may be treated to a lower retention than are support posts (Fig. 8). This evolution will require changes in the way that treated wood is currently marketed and specified. To guide selection of the types of preservatives and loadings appropriate to a specific end-use, the AWWA recently developed Use Category System (UCS) standards [1]. The UCS standards simplify the process of finding appropriate preservatives and preservative retentions for specific end-uses. The UCS standards categorize all treated wood applications by the severity of the deterioration hazard. For example, the lowest category, Use Category 1 (UC1) is for wood that is used in interior construction, completely protected from the weather. At the other end of the spectrum is UC5, which encompasses applications that place treated wood in contact with seawater and marine borers. To use the UCS standards, one only needs to know the intended end-use of the treated wood.

reactions that occur to render the toxic ingredients insoluble in water. The mechanism and requirements for these fixation reactions differ depending on the type of wood preservative. For each type of preservative, some reactions occur very rapidly during pressure treatment, while others may take days or even weeks to reach completion, depending on post-treatment storage and processing conditions. If the treated wood is placed in service before these reactions are completed, the initial release of preservative into the environment may be many times greater than that for wood that has been adequately conditioned. Concerns about inadequate fixation

SUMMARY

The treated wood industry is undergoing a major transition as CCA is replaced in most residential applications. CCA alternatives have been developed and are becoming more widely available. The alternatives rely heavily on copper as the primary biocide, with a range of co-biocides to help protect against copper-tolerant organisms. Studies indicate that the CCA alternatives do release measurable quantities of copper and co-biocide into the environment. However, these components have lower mammalian toxicity than does arsenic, and they are less likely to raise concerns about environmental impacts. As the treated wood industry evolves, it is likely that a wider range of types and retentions of wood preservatives will become available, with the treatment more closely tailored to a specific type of construction application.

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In: Proceedings of Environmental Impacts of Preservative-Treated Wood February 8 - 11, 2004; Orlando, Florida, USA. Florida Center for Environmental Solutions Gainesville, Florida; (pre-conference Proceedings) 1 CD-Rom pp 1-12