



Effect of post-treatment processing on copper migration from Douglas-fir lumber treated with ammoniacal copper zinc arsenate

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ABSTRACT

Migration of heavy metals into aquatic environments has become a concern in some regions of the world. Many wood preservatives are copper based systems that have the potential to migrate from the wood and into the surrounding environment. Some wood treaters have developed “best management practices” (BMPs) that are designed to reduce the risk of migration, but there are few comparative studies assessing the efficacy of these processes. The potential for using various heating combinations to limit copper migration was assessed using ammoniacal copper zinc arsenate treated Douglas-fir lumber. Kiln drying and air drying both proved to be the most effective methods for limiting copper migration, while post-treatment steaming or hot water immersion produced more variable results. The results should provide guidance for improving the BMP processes.

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1. Introduction

Preservative treatments have long been used to protect wood from physical and biological deterioration, but it was not until the middle of the 19th century that the preservatives and the processes used to deliver them into wood improved to the point where they markedly increased performance (Hunt and Garratt, 1967). The preservatives used to protect wood have tended to be broad spectrum biocides in recognition of the need to affect bacteria, fungi, insects and even marine borers. In addition, most biocides have some degree of water solubility that allows them to be sorbed by the target organism and thereby affect some metabolic activity that in turn limits the ability to degrade the wood.

The broad spectrum nature of most preservatives and their water solubility are generally positive attributes in terms of wood protection, but they can also have potential negative effects if they migrate from the wood to affect non-target organisms. The potential for negative impacts can be further magnified if the wood is improperly treated and either contains too much chemical or if excess chemical accumulates on the wood surface. Migration into the soil surrounding treated wood poses relatively little concern

because organic preservatives are rapidly degraded and are rarely detectable beyond 300 mm of the product while metals tend to be diluted to background levels within the same zone (Morrell et al., 2003). The use of treated wood in aquatic environments, however, poses a different challenge because the non-target organisms can be more directly affected by the migrating preservative in the water column (Brooks, 1997, 2003, 2004). Copper is particularly problematic because of its potential effects on the ability of migratory salmon to locate their native streams.

There is a substantial debate about the potential risks associated with treated wood used in aquatic applications. Brooks has written extensively on the subject and generally found that copper entering aquatic environments from treated wood does not exceed minimum effects levels except where large amounts of treated wood are employed in water bodies with low flow (Brooks, 2011). There is also a general understanding that preservatives in runoff from treated wood subjected to precipitation increase rapidly after installation, but then fall to background levels relatively quickly (Lebow, 1996). Thus, the greatest risk to aquatic life occurs shortly after installation. These findings have been disputed and there are some who feel that treated wood use in these applications should be banned, while ignoring potential inputs from alternatives such as galvanized steel, plastic composites, or other materials.

Concerns about the potential for preservative migration have led to the development of a series of practices designed to reduce

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the environmental footprint of treated wood. These efforts have especially concentrated on minimizing preservative migration shortly after installation. Best Management Practices (BMPs) were originally developed by the Western Wood Preservers Institute (WWPI) and were designed to reduce over-treatment and remove surface deposits that might be more easily dislodged once the wood was in service (WWPI, 2006, 2011). These processes generally employ long vacuums at the end of the treatment cycle to hasten excess solution recovery coupled with various heating regimes designed to accelerate evolution of co-solvents and foster deposition of the metal components. BMP processes include steaming, kiln drying, and hot water soaks (WWPI, 2011).

Although there is science behind the BMPs in terms of immobilizing metals in wood, the processes included in the standards have developed empirically based upon the capabilities of individual treatment facilities. As a result, the ability of a give process to affect subsequent migration of preservative components has not been examined on carefully controlled material. These data will be essential for continued improvement of the BMPs.

Ammoniacal copper zinc arsenate (ACZA) was developed in the 1980's, specifically for impregnation of difficult to treat wood species, but this formulation replaced ammoniacal copper arsenate, a system developed in the 1930's for the same purpose (Morgan, 1989). These systems use ammonia to solubilize copper for impregnation into the wood. The ammonia also tends to improve preservative penetration through a combination of wood swelling and dissolution of debris on the pits connecting individual cells. Both systems have been primarily used to treat Douglas-fir for industrial applications, although there have been recent efforts to use ACZA for other species. A small proportion of the copper in ACZA does react with the wood, but deposition of the metal components of ACZA into the wood primarily occurs as the ammonia evaporates (Kumar et al., 1996; Jiang, 2000; Jin and Archer, 1991; Ruddick, 1996, 2003; Thomason and Pasek, 1997). The copper becomes insoluble, carrying the zinc and arsenic out of solution as well. Although zinc was initially added to reduce corrosion, there is evidence that it results in reduced copper migration (Lebow and Morrell, 1995).

While ACZA has been used for over 30 years and BMP processes have been available for this system since 1996, there is relatively little comparative data on the ability of the various BMP processes to immobilize copper. In this report, we describe an evaluation of various BMP processes on copper migration from ACZA treated wood subjected to simulated rainfall. Copper was the focus of this study because it is the heavy metal of greatest concern when treated wood is used in aquatic applications (Brooks, 2011).

2. Materials and methods

2.1. Lumber preparation

Twelve Douglas-fir boards (*Pseudotsuga menziesii* (Mirb) Franco) (nominally 50 mm × 150 mm × 4 m long [actually 38 mm × 140 mm × 4 m]) were commercially incised to a depth of 10 mm at a density of 800 incisions/m². The boards were conditioned to constant weight at 23 °C and 65% relative humidity before being randomly allocated to one of two treatment groups of six boards each (ACZA at 4.0 kg/m³ or 6.4 kg/m³). These retentions correspond to the retentions specified in the American Wood Protection Association for above ground and ground contact exposure listed as Use Categories UC3b and 4a (AWPA, 2013). Each board was end-coated with a two-part epoxy to retard longitudinal preservative penetration.

The boards were commercially treated to the target retention in accordance with American Wood Protection Association Standards

U-1 and T-1 (AWPA, 2013). The goal was to complete the pressure treatment cycle without proceeding to any post-treatment vacuums or heating that might accelerate ammonia loss to hasten copper deposition.

Each of the treated boards was immediately cut into ten 300 mm long sub-samples. Each sub-sample was weighed and labeled before being sealed in a plastic bag and frozen at −10 °C until needed.

2.2. Post-treatment with BMPs

Frozen sub-samples were defrosted before being subjected to one of nine treatments listed in the Western Wood Preservers Institute Best Management Practices requirements.

1. Air-drying: Samples were placed on stickers to encourage air-flow at ambient temperature (20–25 °C) and conditioned to a target moisture content below 19% over four weeks.

2–3: Kiln drying: Samples were stickered to allow air-flow and placed in a steam heated kiln to be dried on a three-day cycle at a dry-bulb temperature of 71.1 °C with a wet-bulb depression of 16.7 °C or a one-week kiln schedule at a dry-bulb temperature of 48.9 °C and wet-bulb depression of 5.6 °C. The latter cycle limited drying, but the lower temperature should have encouraged ammonia loss. Both of the schedules resulted in wood moisture contents below 19%.

4–6: Steaming: Samples were stickered and subjected to 1, 3 or 6 h of steaming at 104.4 °C.

7–8: Hot water bath: Samples were soaked in water at 100 °C for 1 or 3 h.

9–10: Ammonia bath: Samples were soaked in aqueous 1% ammonia at 100 °C for 1 or 3 h.

The samples were placed in individual bags after being subjected to a given BMP and frozen until needed. Each treatment was replicated on a sample cut from each parent board treated to a given retention.

2.3. Simulated rainfall tests

The samples were warmed overnight to room temperature before the potential for metal migration was evaluated in a specially constructed overhead leaching apparatus that applied a controlled amount of simulated rainfall at a desired temperature (Fig. 1). Previous studies (Simonsen et al., 2008) showed that preservative migration was independent of both temperature and

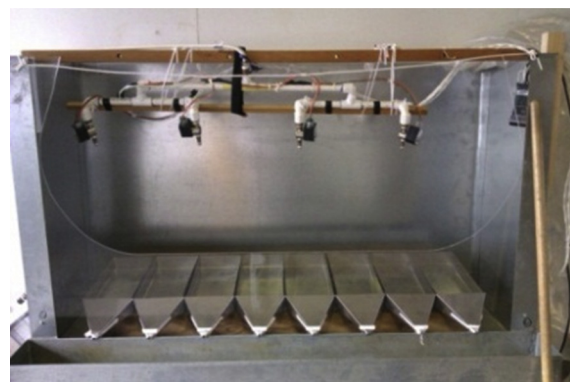


Fig. 1. Overhead leaching apparatus used to evaluate the effects of BMP procedures on copper migration from ACZA treated wood showing slots at the bottom to hold test pieces and spray nozzles overhead to deliver simulated rainfall.

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