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Evaluation of effect of leaching medium on the release of copper, chromium, and arsenic from treated wood

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Abstract

There is increasing public concern about environmental contamination from preservative treated wood due to release of toxic preservative components to the environment. Leaching of wood preservatives from treated wood in service can be affected by a number of factors such as wood and preservative treatment characteristics and properties of water and soil substrate in which treated wood is placed i.e. salinity, pH, and temperature. Laboratory leaching tests usually require distilled or deionized water for leaching procedure however treated wood is generally exposed to different types of water and soil conditions. This study evaluates the release of copper, chromium and arsenic elements from chromated copper arsenate (CCA)-treated wood exposed to either distilled water, tap water, sea water or humic acid. Leaching tests were conducted in laboratory conditions using wood blocks treated with CCA wood preservative at either low or high retention levels. Results showed that tap water resulted in less preservative release when compared to the other leaching media used in the study. Humic acid was the most effective medium causing more element leaching. The percentage of components leached was always higher in wood blocks treated at the high retention in comparison with the low retention level. Our results from the leaching tests can be important in developing more realistic standard leaching methods to evaluate preservative components to be released from treated wood.

Keywords: Distilled water; Tap water; Sea water; Humic acid; CCA; Leaching

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1. Introduction

Current leaching methods for evaluating preservative release from treated wood typically specify use of distilled water or deionized water that does not represent the ions present in most natural environments [1,2]. Although many factors affect the amount of preservative released from treated wood such as exposure time, preservative components, preservative retention, surface area and wood properties, characteristics of leaching media or the environment in which the wood is exposed particularly pH, salinity, and temperature are of importance in determining released amount of preservatives [3–5].

Water is the key to the leaching of preservative components from the wood and it can carry organic and inorganic compounds into the wood and affects leaching rates. A number of study have been done to evaluate the effects of leaching media on the release of a wood preserving and calcium precipitating agent, *N,N*-hydroxynapthalimide (NHA) from treated wood [1]. A study by Kartal et al. [1] showed that sea water and tap water containing higher ion concentrations than distilled water resulted in less leaching of NHA from treated wood specimens. Kartal and Imamura [2] also found that tap water leaching resulted in more boron leachability from boron and NHA-treated wood specimens compared to distilled water, however tap water caused less NHA release from treated specimens.

Sea water in contact with treated wood in service affects release of copper, chromium and arsenic elements from chromated copper arsenate (CCA) treated wood [3]. Lebow

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et al. [6] found that sea water had a mixed effect on leaching of the elements of CCA. Their studies showed that release rate of copper was much greater in sea water than deionized water however arsenic release was greater in deionized water and chromium was not affected by sea water. Lebow and Kartal [7] showed that copper, chromium, and arsenic losses from CCA treated piles were 0.5, 0.4, and 0.4 μg/cm^2/day, respectively, after 14-day leaching with sea water with a salinity of 23 ppt at 2 °C. Irvine and Dahlgren [8] stated that the increased formation of complexes between chloride coming from salt solution and copper might explain the increased leaching of copper at salinities above 24 ppt. Plackett [9] indicated that inorganic salts as leaching solutions caused increased copper leaching when compared to distilled water and copper leaching increased with increased salt solution concentration.

CCA treated wood is also used in ground contact applications where the surrounding soil might elevate release of CCA components because suspended or solubilized compounds from soil may solubilize preservative components [3]. When treated wood is placed in soil, complicated leaching and chemical reactions occur increasing the depletion of the preservative from the wood. Soil acidity, presence of organic acids and calcium, magnesium, or potassium salts and soil texture are important factors which might influence preservative leaching [10]. It is also well known that organic acids can remove effectively most of CCA components from treated wood [11–13]. Cooper et al. [14] have stated that organic matter and organic acids from silage and compost are effective at extracting CCA components from treated wood. They also suggest that wet organic sites with varying amounts of humic matter or humic acid affect the efficacy of treated wood due to increased preservative leaching.

This paper evaluated the effects of distilled water, tap water, sea water and humic acid on copper, chromium, and arsenic leaching from sugi sapwood treated with CCA at low and high retention levels.

2. Materials and methods

2.1. Preservative treatments of wood blocks

Wood blocks, 20 (radial) by 20 (tangential) by 10 (longitudinal) mm, were prepared from sapwood portions of sugi (*Cryptomeria japonica* D. Don) lumber. The blocks were free of knots, and visible concentration of resins, and showed no visible evidence of infection by mold, stain, or wood-destroying fungi. The blocks were conditioned to 12% moisture content (MC) in a conditioning room maintained at 23 °C and at 65% relative humidity (RH) and all blocks were numbered and weighed to the nearest 0.01 g.

Wood blocks were treated using an oxide-based either 0.9 or 2.3% CCA-Type 2 solution in order to get low or high preservative retentions in the wood. The original CCA Type 2 solution at 75.4% concentration was obtained from Koshii Preserving Co., Japan. CCA Type 2 preservative contains 18–22% CuO, 33–38% CrO_3, and 42–48% As_2O_5 as specified by Japanese Industrial Standards (JIS) K 1570 [15]. The formulation of CCA Type 2 by the Japanese standard is the same as CCA Type B as specified by American Wood Preserver's Association (AWPA) P5-02 [16].

The blocks were placed in a treatment desiccator, subjected to 10 cm Hg vacuum for 20 min, the treating solution was introduced and the vacuum was released. After 30 min, the blocks were removed from the solution, wiped lightly to remove surface preservative solution, immediately weighed to the nearest 0.01 g, and the amount of preservative absorbed by the blocks was calculated. The treated blocks were stored in plastic bags at 23 °C for a fixation period of 2 weeks.

After post-treatment conditioning, 10 blocks were randomly selected from both treatments (0.9 and 2.3% CCA) to determine chromium, copper, and arsenic retention. Each block was ground to pass a 30-mesh screen. Ground wood (0.1 g) was then dissolved completely in 10 ml of 65% HNO_3. The sample was transferred into a conical flask equipped with a water cooler to prevent loss by volatilization during the dissolution process. The flask was then heated on a heating plate for about 4 h until the sample had dissolved completely. The solution was analyzed for copper, chromium, and arsenic content to determine the initial amounts of the elements in the samples using an Ion Coupled Plasma Spectrometer (ICP SPS7800 SII) (Seiko Instruments Inc., Japan).

2.2. Leaching of treated wood blocks

Leaching tests were conducted according to JIS A 9201 [17]. All treated blocks were reconditioned at 23 °C and 65% RH for 2 weeks before the leaching tests. Leaching involved immersing wood blocks in distilled water, tap water, synthetic sea water adjusted to a salinity of 34 ppt (Table 1) or humic acid (1%), and stirring with a magnetic stirrer (400–500 rpm) at 27 °C for 8 h followed by drying at 60 °C for 16 h. This cycle was repeated 9 times. After each leaching cycle, leaching medium was renewed to a ratio of 10 volumes of leaching medium to 1 volume of wood and the leachate was sampled to determine the amount of copper, chromium, and arsenic using an Ion Coupled Plasma Spectrometer (ICP SPS7800 SII) (Seiko Instruments Inc., Japan). The percent leaching of copper, chromium and arsenic from the blocks was calculated based on the initial amount of elements in unleached wood blocks.

Humic acid was obtained from Aldrich Chemical Company, Inc., Milwaukee, Wisconsin, USA It was extra pure and analytical grade and used without any preliminary purification and further modification.

As a measure of hardness, the tap water was analyzed for calcium carbonate ($CaCO_3$) concentration using an Ion