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IMPROVING THE PERFORMANCE OF WOODEN DECKS THROUGH COATINGS

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Abstract

Fourteen different semi-transparent stain products were applied to CCA, ACQ, CA and untreated pine wood and evaluated for their performance through a combination of laboratory tests, accelerated weathering tests and natural exposure. Some coatings are more effective than others in reducing water uptake and leaching and perform differently on the above mentioned preservative treatments. The paper focused on the result of three month accelerated and natural weathering. The result shows that most coatings were highly effective in minimizing copper leaching from ACQ, and CA treated samples and chromium and arsenic from CCA treated wood. However, some coatings that were effective for other preservative components were less effective in reducing copper leaching from CCA wood samples.

1. Introduction

Wood in exterior applications is subjected to decay (decay fungi and insects) and weathering agents (rain and UV rays). Protecting wood from decay organisms is achieved by applying preservatives (fungicides and insecticides) to wood. Protection from the weathering factors is achieved by the use of coatings (Satas and Tracton 2001). Coatings applied on preservative treated wood can also minimize or prevent leaching of the preservatives (Taylor et al. 2001, Challener 2005, Cobb and Levenson, 2005, Stefanovic 2005). In order to enhance this beneficial application of the coatings, any chosen coating has to be compatible with the wood surface (Anonymous 1999).

Decks make up a vast amount of residential wood taken out of service because they are the structures most severely exposed to direct sun and rain (Morrell 2001). The average service life of decks in North America is about 10-15 years (Scarborough 2005). Although preservative treatment has the potential to triple service life of decks, people still replace structurally sound decks mainly because of their appearance (Williams and Feist 1993). Application of a compatible coating on treated wood can prolong good appearance and decrease environmental concerns related to preservative leaching and early disposal of the wood (Stalker 1993, West 2001, Townsend et al. 2005).

Application of semi- transparent penetrating stains has been recommended for wooden decks, because penetrating stains do not crack and peel during weathering (Williams and Feist 1993, 2000, Rijckaert et al. 2001, Feist 2002). Also, semi-transparent stains include some pigment to protect the wooden surface from UV and possibility to show the beauty of wood grain. The ability of penetrating stains to prevent leaching of preservative treatment is not clear. This study evaluated a number of available commercial penetrating stains through laboratory, accelerated and natural weathering tests to determine their capability to reduce leaching of arsenic, chromium and copper from CCA treated wood and copper from ACQ and CA treated wood.

2. Materials and Methods

Even though the vast majority of decks in Canada are made of ACQ or CA treated SPF (spruce, pine, and fir) lumber, the proposed research was performed on southern pine due to its low paint-holdability and high species density (William et al.1996). It is also assumed that pronounced paint cracking and checking can be caused by great variability between the densities of early-wood and late-wood. It is also expected that coatings which perform well on southern pine, will work well on other wood species such as SPF.

Experiments were performed on flat grained sapwood of southern pine (SP). Nominal1 inch x 6 inch x 16 foot boards were cut in four 1 inch x 6 inch x 4 foot pieces. Three pieces were treated, each with a different preservative and one was used as an untreated (control) sample. Preservatives used were as follows: CCA-C (47.5% CrO_3, 18.5% CuO, and 34% As_2O_5), ACQ-C (66.7% copper oxide, 33.3% quat as alkyl dimethyl benzyl ammonium chloride) and CA-B (96.1% copper, 3.9% Tebuconazole). CCA and ACQ were treated to above ground retention and CA treated close to contact ground retention. Samples were allowed to fix for one week at 50˚C and 95% relative humidity.

A set of screening test samples [(3 preservative treatments + untreated control) x 14 coatings x 2 replicates] were used for initial stain screening tests. The screening test samples were coated on all sides, weighed and submerged in water for two weeks. Their weights were recorded and the leachate was collected for analysis after one, three and fourteen days.

The densities of the coatings were measured by a hydrometer. For a qualitative wetting measurement, 2µl of each coating was placed on both late wood and early wood of untreated control samples to estimate rate of coatings wetting and absorbency into wood. According to water uptake values, leaching preservative amounts, wetting test results, and coatings characteristic such as: resin type, density, coatings base (water or solvent), and surface tension, five different coatings, covering the range of the chemical and physical properties, were selected for the field tests, and four coatings were selected for accelerated weathering tests (Table 1).

The five selected coatings for exterior exposure were applied on the face exposed to the weathering and to end grain. Three replicates for each treatment (CCA, CA, ACQ and untreated control) and coating were exposed to natural weathering and one replicate was kept as a control inside the lab (Dawson et al. 2005).

Figure-1- Natural weathering set up

The accelerated weathering was performed according to modified prEN-927-6 test over a period of 12 weeks. One-week testing cycles include three-day UV radiation (UV-A 340nm), one-day water spraying, and three-day freezing. This European standard test has been reported as a good accelerated weathering test, closely reassembling natural weathering of wood coatings (Podgorski, 2004).

Wood leachates obtained from the natural weathering tests were collected after one, two and three months and in the case of the accelerated tests on a weekly basis. The leachates were analyzed by Inductively Coupled Plasma-Atomic Emission Spectrometry (ICP-AES).

Permeability of each coating was expressed by moisture excluding efficiency. Water uptake of coated and control samples were measured for the screening samples and after extended dry and wet periods of natural weathering and each week of accelerated weathering tests. Moisture excluding efficiency is calculated according to the following equation:

$$\%MEE = \left(1 - \left\{\frac{wt_{coated} - wt^{init}_{coated}}{wt_{control} - wt^{init}_{control}}\right\}\right) \times 100$$

Where:

%MEE	=	moisture excluding efficiency (%)
Wt_{coated}	=	weight of coated specimen after specific water adsorption period (g)
Wt^{init}_{coated}	=	initial weight of coated specimen (g)
$Wt_{control}$	=	weight of uncoated specimen after specific water adsorption period (g)
$Wt^{init}_{contro\ l}$	=	initial weight of uncoated specimen (g).

3. Results and discussion

3.1 Screening

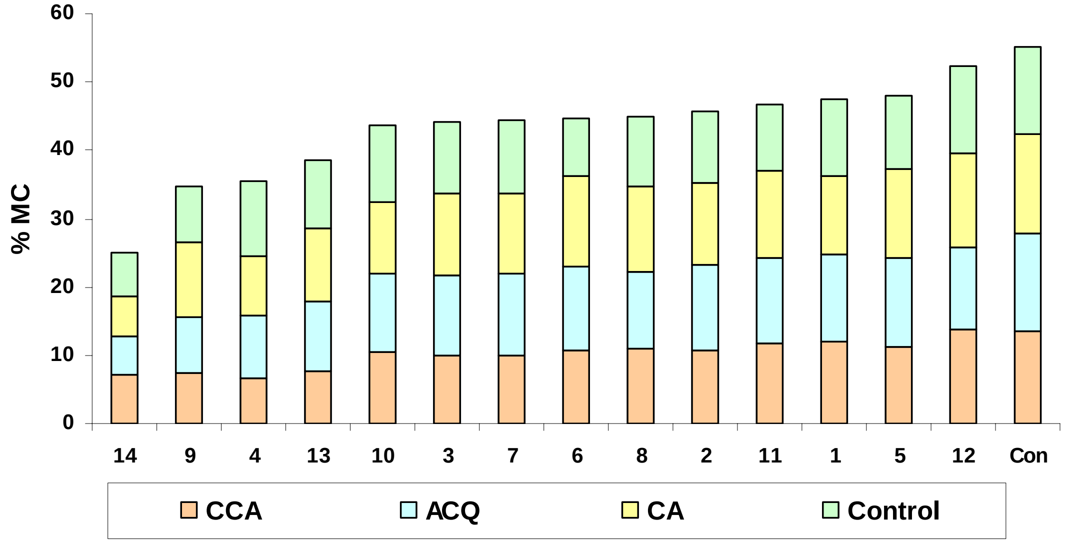
Table-1 shows the resin type and coating base (water or solvent) and summarizes the result of screening tests. According to these results, coatings # 2, 4, 5, 9 and14 were chosen for natural and # 2, 4, 5 and 9 used for the first set of accelerated weathering.

Table- 1

	Resin Type	Base	Specific gravity	% Moisture Excluding Efficiency	Leaching Reduction
1	Alkyd	W	1.02	12	Good
2	Alkyd-Acrylic	W	1.02	11	Average
3	Alkyd	S	0.98	21	Average
4	Styrene- Acrylic	W	1.03	23	Good
5	Alkyd	S	0.85	10	Bad
6	Alkyd	S	0.87	18	Average
7	Alkyd	S	0.85	19	Average
8	Alkyd	S	0.88	18	Average
9	Alkyd	S	0.92	24	Good
10	Alkyd- Acrylic	W	1.09	19	Average
11	Alkyd	S	0.85	14	Bad
12	Alkyd	W	1.01	4	Bad
13	Alkyd	S	0.95	24	Average
14	Polyurethane	W	1.04	40	Good

Figure 2 shows the moisture content change of coated-treated and untreated screening samples after one day water immersion. Coating performances were not only different from each other, but also their interactions with different treatments were different. In general coating number 14 was able to protect the wood surface from moisture absorption better than the other coatings, and coating number 4 showed the best performance on CCA-treated wood, but it was not the best on the other treatments.

Figure 2: Average moisture content change of screening samples after one day

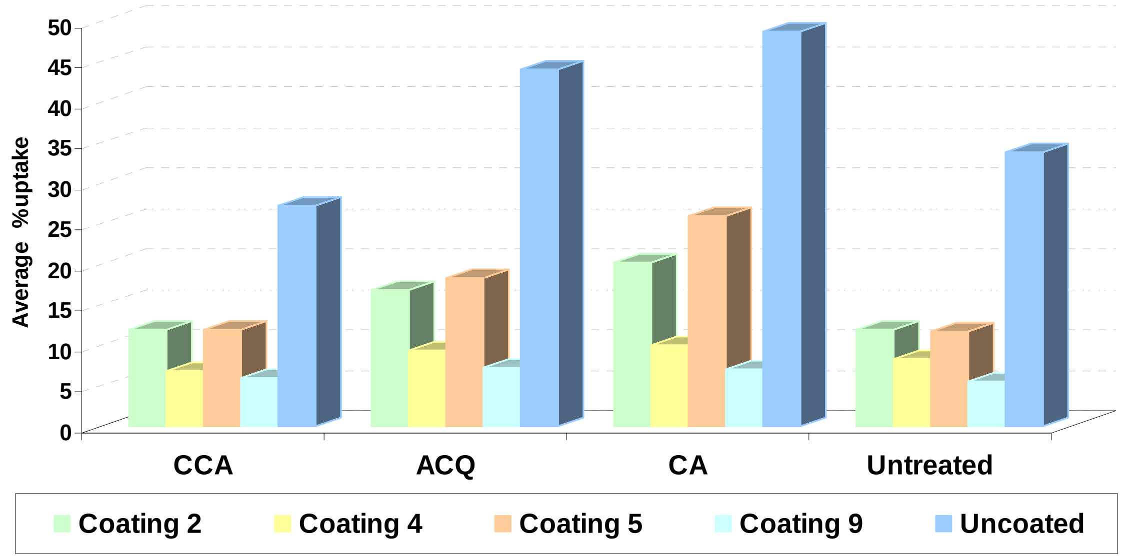


In general, the results of screening tests were consistent with those for the three months of natural and accelerated weathering and this quick laboratory tests was useful for predicting actual long term weathering performance.

3.2 Accelerated Weathering

Result of three months (twelve cycles) of accelerated weathering is represented in Figures 3-8. In all weathering and laboratory uptake result (Figures 2, 3 and 9), uncoated CCA and controls (untreated) samples had lower uptake than uncoated ACQ and CA samples

Figure 3: Average moisture uptake per accelerated weathering cycles



In terms of leaching prevention coating number 9 was the best and coating number 5 was the worst except for leaching of copper from CCA-treated wood samples (Figures 4-8).

Figure 4: Leaching of Cr from CCA-treated accelerated weathering samples

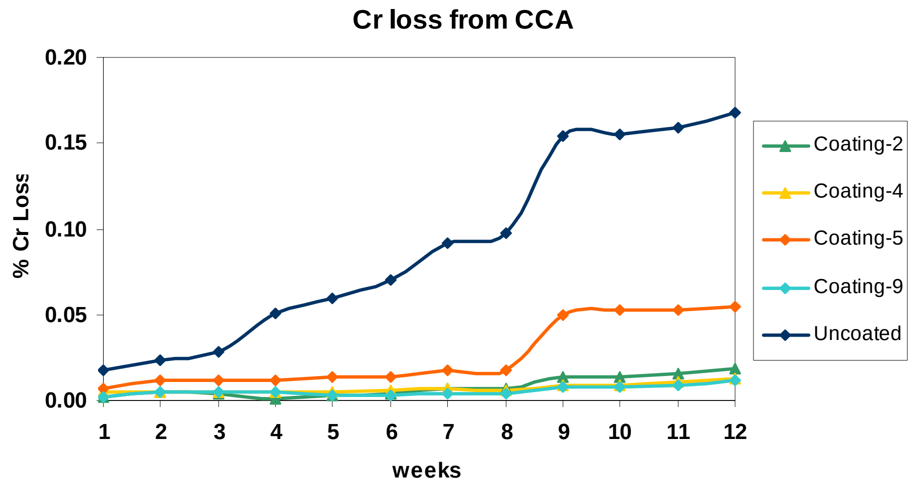


Figure 5: Leaching of As from CCA-treated accelerated weathering samples

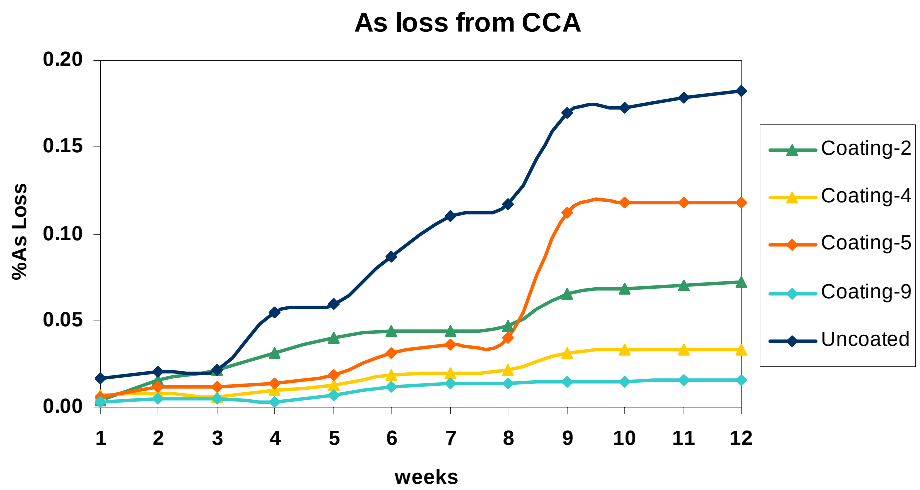


Figure 6: Leaching of Cu from CCA-treated accelerated weathering samples

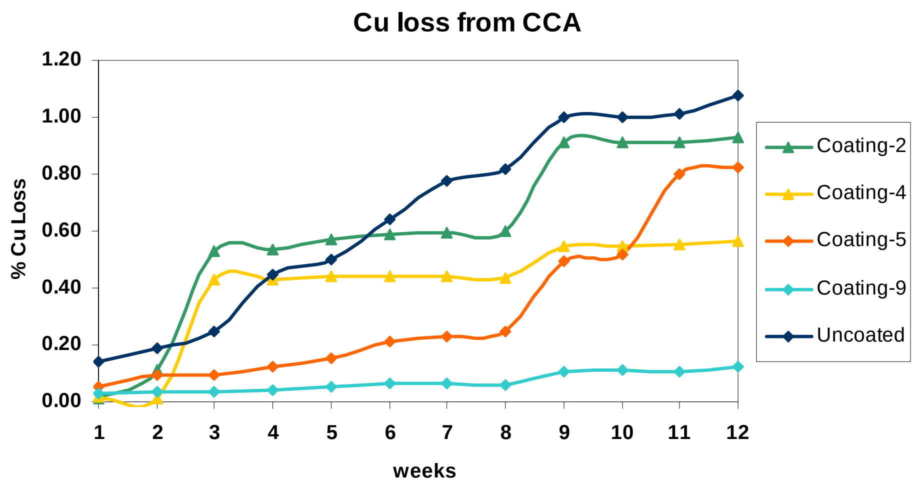


Figure 7: Leaching of Cu from ACQ-treated accelerated weathering samples

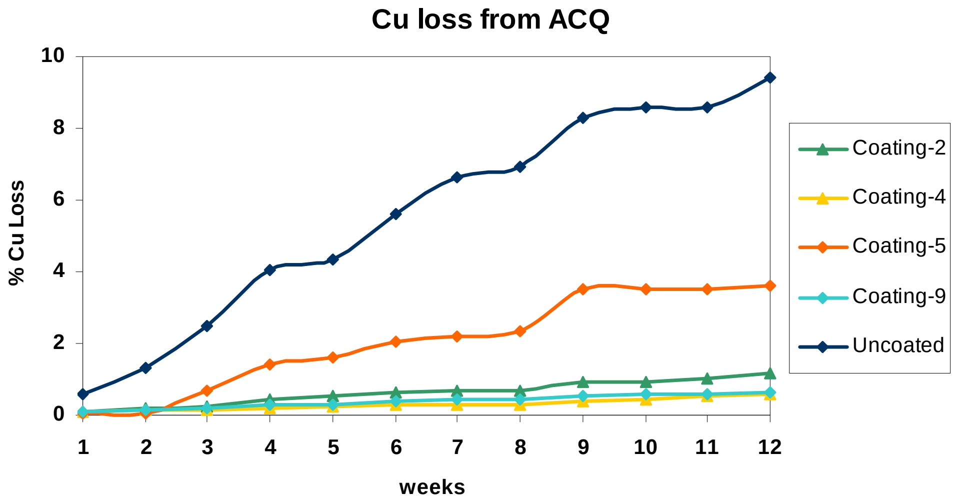
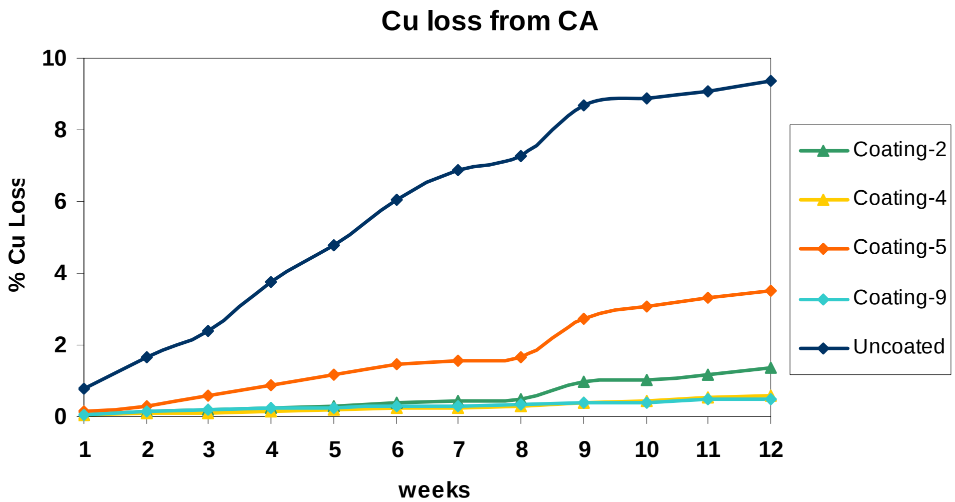


Figure 8: Leaching of Cu from CA-treated accelerated weathering samples

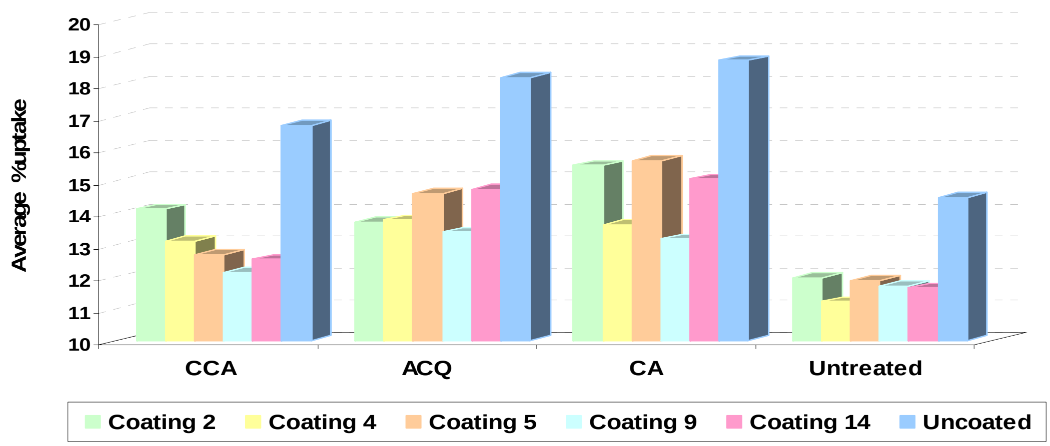


Although the level of total copper leaching from ACQ and CA treated wood was noticeably higher than for CCA, most coatings were effective in minimizing copper leachate from ACQ and CA samples but there was some discrepancy among coatings performances in preventing copper leaching from CCA samples.

3.3 Natural weathering

Data on 2 months of water uptake of CCA, ACQ, CA and untreated wood (natural weathering) for all five coating and uncoated samples are presented in Figures 9. Generally similar trends were seen as for the accelerated weathering.

Figure 9: Moisture content change of natural weathering samples after two months of natural weathering



Cumulative leaching of CCA, ACQ and CA components after three months of natural exposure are presented in Figures 10-14. In terms of percent leached from the sample, the losses of all three components decrease with application of coating in all cases. Since the presented values for CA are based on the leaching of treated wood with higher than above ground retention, they overestimate the losses of copper expected from the CA treated wood for above ground retention that would be used in service.

Figure 10: Leaching of Cr from CCA-treated natural weathering samples

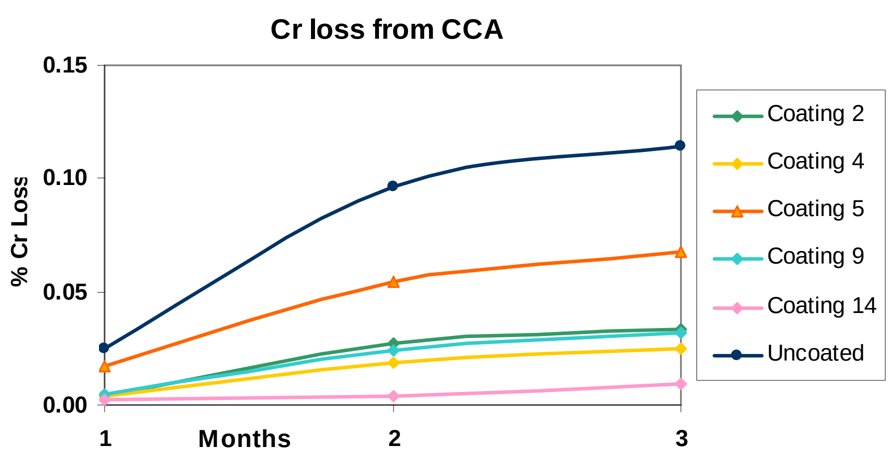


Figure 11: Leaching of As from CCA-treated natural weathering samples

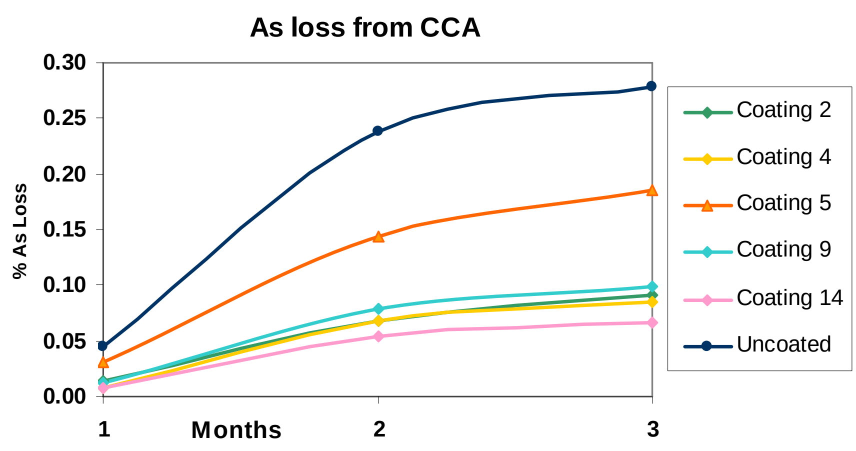


Figure 12: Leaching of Cu from CCA-treated natural weathering samples

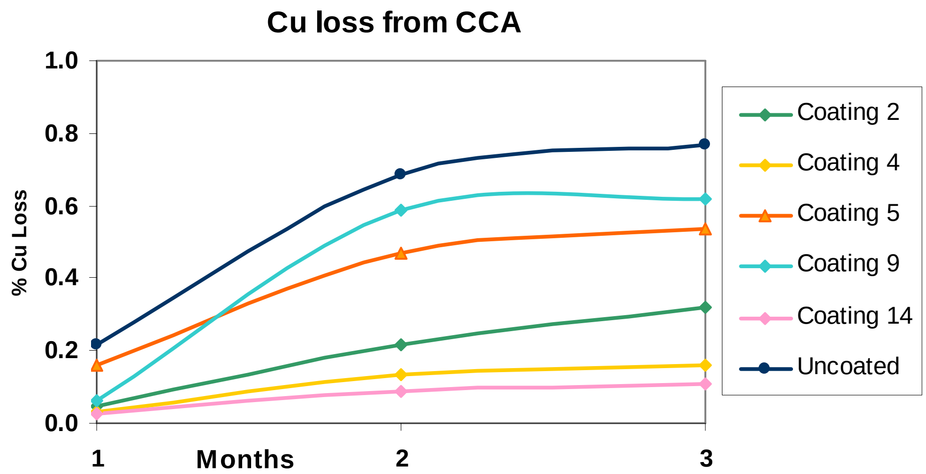


Figure 13: Leaching of Cu from ACQ-treated natural weathering samples

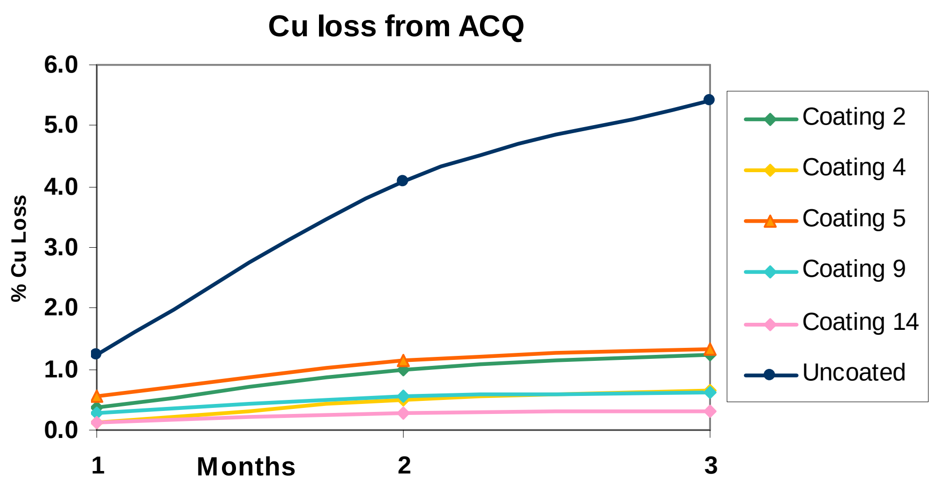
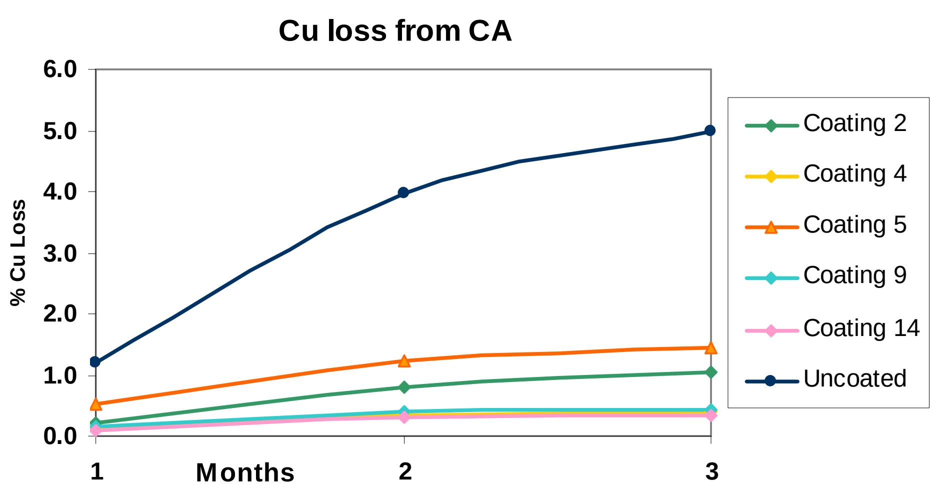


Figure 14: Leaching of Cu from CA-treated natural weathering samples



Again, the natural weathering results were similar to those seen for the accelerated weathering. These results are of practical importance, since they indicate that penetrating stains are highly effective to reduce leaching of preservative components from deck structures, at least over the short term. These studies will be continued to include more coatings in the accelerated weathering test and to evaluate their longer term natural weathering performance.

4. Conclusion

Most coatings were effective in reducing copper leaching from CA and ACQ samples. Although all coatings significantly reduce leaching of arsenic and chromium from CCA, they have not shown the same ability to reduce copper leaching from CCA. In general CCA and control samples have lower moisture uptake without coatings than ACQ and CA samples which indicates that ACQ and CA samples should be protected by a water repellent or a coating when considering for direct exposure to rain (exterior application). Some coatings perform better than others in regard to moisture exclusion and leaching reduction. This study will continue to determine how coating characteristics and wood surface properties interact, so recommendations can be made on the best coating types for different treatments.

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