Leaching of flakeboard produced from recycled CCA-treated wood into deionized water

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Abstract

The disposal of preservative-treated wood is becoming a larger issue for the forest products industry due to increasing public concern and scrutiny as well as costs associated with traditional disposal, i.e., landfilling. Recycling of preservative-treated wood has great potential. In this study, flakeboard was produced from decommissioned guardrail posts that had been treated with chromated copper arsenate (CCA). The leaching characteristics of chromium, copper, and arsenic from flakeboards manufactured from five different ratios of recycled CCA-treated wood and untreated virgin southern pine wood were investigated. Five ratios of recycled CCA-treated wood and virgin, untreated wood were used for flakeboard furnish. The ratios were 100:0, 75:25, 50:50, 25:75, and 0:100. The guardrails generally showed higher amounts of CCA in the outer horizontal areas and the middle vertical regions of the guardrail posts. As expected, the furnishes with greater amounts of CCA-treated wood had higher leaching values.

More than 6 billion board feet (BBF) (14.2 million m^3) of lumber is treated with chromated copper arsenate (CCA) every year in the United States (Micklewright 1998). The average service life of CCA-treated wood is 25 years. At the end of the life cycle of treated wood, it faces a disposal problem. Many scientists have investigated recycling methods to reuse this waste material for value-added products. The recycling of decommissioned CCA-treated wood into composite panels is regarded as one of the most viable options to mitigate disposal problems (Felton and De Groot 1996, Cooper 1999). At the same time, the residual CCA content in the recycled wood can still offer effective protection against decay and insects (Cooper 1997, Cooper et al. 1996). However, the leaching characterization of these recycled composite products needs to be further investigated.

Theoretically, once CCA-treated wood is dried, the CCA is leach resistant under normal (most) conditions (Hartford 1986). CCA resists leaching in service because of complex chemical reactions that take place within the treated wood. However, extended weathering causes a reduction of CCA content in the material exposed to exterior service conditions. The objectives of this study were to examine the residual CCA distribution in decommissioned guardrail posts and the leaching properties of flakeboard made from decommissioned CCA-treated wood.

Materials and methods

Raw materials

Guardrail posts, manufactured from southern pine (*Pinus* spp.), were obtained from Arnold Forest Products Company in Shreveport, Louisiana. The posts, which had been treated with CCA at 0.5 pcf (8 kg/m^3), went in service in May 1986 in Abilene, Texas, and were removed in September 1999. The posts were about 69 inches (175.3 cm) long with a top diameter range of 6-1/2 to 7-1/2 inches (16.5 to 19.0 cm), and a bottom diameter range of 7 to 8-3/4 inches (17.8 to 22.2 cm). The mean specific gravity of the poles was 0.51 and was determined in the ovendry condi-

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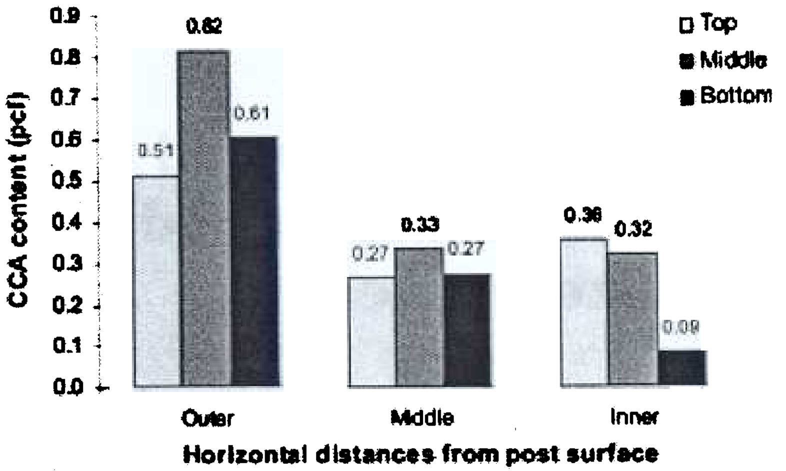

Figure 1. — CCA retention of guardrail posts from different horizontal (outer, middle, and inner) and vertical (top, middle, and bottom) locations.

Table 1. Experiment design.

Treatment	Ratio of CCA flakes vs. untreated flakes in percent
Group 1	100 : 0
Group 2	75 : 25
Group 3	50 : 50
Group 4	25 : 75
Group 5	0 : 100

tion. These posts had been installed approximately 38 inches (96 cm) into the ground. After passing under an electronic metal detector, foreign metal objects were manually removed and the posts were transported to Lee Memorial Forest in Franklinton, Louisiana, for processing into lumber. Twenty-two posts were sawn into 1-inch- (2.5- cm-) thick lumber using a WoodMizer® sawmill, and three posts were retained for chemical analyses. Three disks, each 1 inch (2.5 cm) thick, were cut from the top, middle, and bottom of the posts and used for later chemical analyses. The top and bottom disks were removed 1 foot (30 cm) from the top and bottom of the guardrails, respectively. The middle disks were removed from the vertical center. Fresh southern pine lumber was purchased at a local retail lumber store.

Panel fabrication

Both CCA-treated lumber and virgin southern pine lumber were used to generate flakes 0.05 by 1.0 by 3.0 inches (0.1 by 2.5 by 7.6 cm) in dimensions, with a laboratory ring-flaker. All flakes were dried to 4 percent moisture content at 217 ± 4°F (102 ± 2°C) for 3 hours and screened to remove fines (material passing through a screen with 1/4 in.^{2} [1.6 cm^2] openings). The phenol-formaldehyde (PF) resin had a solids content of 52 percent and viscosity of 400 cps, and a pH of 11.78. A 4.5 percent adhesive based on ovendry weight of flakes was used to bond all panels after ovendrying. Flake mats were hand-formed in a frame (16.5 by 20 in./41.9 by 50.8 cm). Recycled CCA-treated flakes and untreated flakes were mixed at five ratios by weight: 100, 75, 50, 25, 0 percent treated wood content (**Table 1**). Mats were hot-pressed for 4 minutes until stops at 62 psi (427 kPa) with a platen temperature of 370°F (187.8°C). Flake orientation was random. The panel mean specific gravity was 0.76 as determined in the ovendry condition.

Testing methods

Leaching tests were performed on flakeboard specimens according to modified procedures of the American Wood-Preservers' Association Standard E11-97 (AWPA **2000**). No stirring was done so values presented here represent static leaching values. Three test blocks with dimensions of 1/2 in.^{3} (8.2 cm^3) from each panel group were tested for leachability. The samples were submerged into 50 mL of deionized water. Three replications were performed. The water was replaced with an equal amount after 1, 7, 14, 21, and 28 days. Water samples were collected after each water replacement, and then were allocated into three equal parts of 15 mL each and analyzed for chromium, copper, and arsenic by inductively coupled plasma optical spectrometry (ICP).

The CCA retention test was conducted with 10 samples from each experimental panel group (Groups 1 to 5). The samples measured 1/2 in.^{3} (8.2 cm^3), and the entire samples were tested for percentage of metals and multiplied by panel density to determine retention. Also, three guardrail posts were selected and disks were removed at three vertical locations (top, middle, and bottom) from each guardrail. From each disk, samples were removed at three horizontal locations (outer, middle, and inner) in a straight radial line. The outer and inner samples were immediately adjacent to the outside and pith of the disks, respectively. The middle samples were equal distance from the outer and inner samples. Therefore, a total of 9 samples per guardrail were tested for CCA retention, according to AWPA A-21-00 (**2000**), using ICP.

Results and discussion

CCA retention

Copper oxide, chromium trioxide, and arsenic pentoxide retention in the flakeboard samples is shown in **Table 2**. The elemental concentration of CCA gradually decreased from Group 1 to Group 5, as the proportion of CCA-treated wood in the flakeboard furnish diminished. As is typical for CCA-treated wood, the amounts of chromium trioxide were higher than the other two metal elements in all panel groups containing CCA-treated wood.

Figure 1 shows the total copper oxide, chromium trioxide, and arsenic pentoxide retention in CCA-treated guardrail posts from different horizontal positions (outer, middle, and inner) and vertical positions (top, middle, and bottom). In general, higher amounts of CCA were found in the outer horizontal areas and middle vertical regions. The horizontal sample location factor was significant at $\alpha = 0.05$ (**Table 3**). The vertical and horizontal trends of the residual CCA in the guardrails is in agreement with previous findings by Roliadi et al. (2000) on 5- and 25-year-old creosote-treated utility poles. This is largely

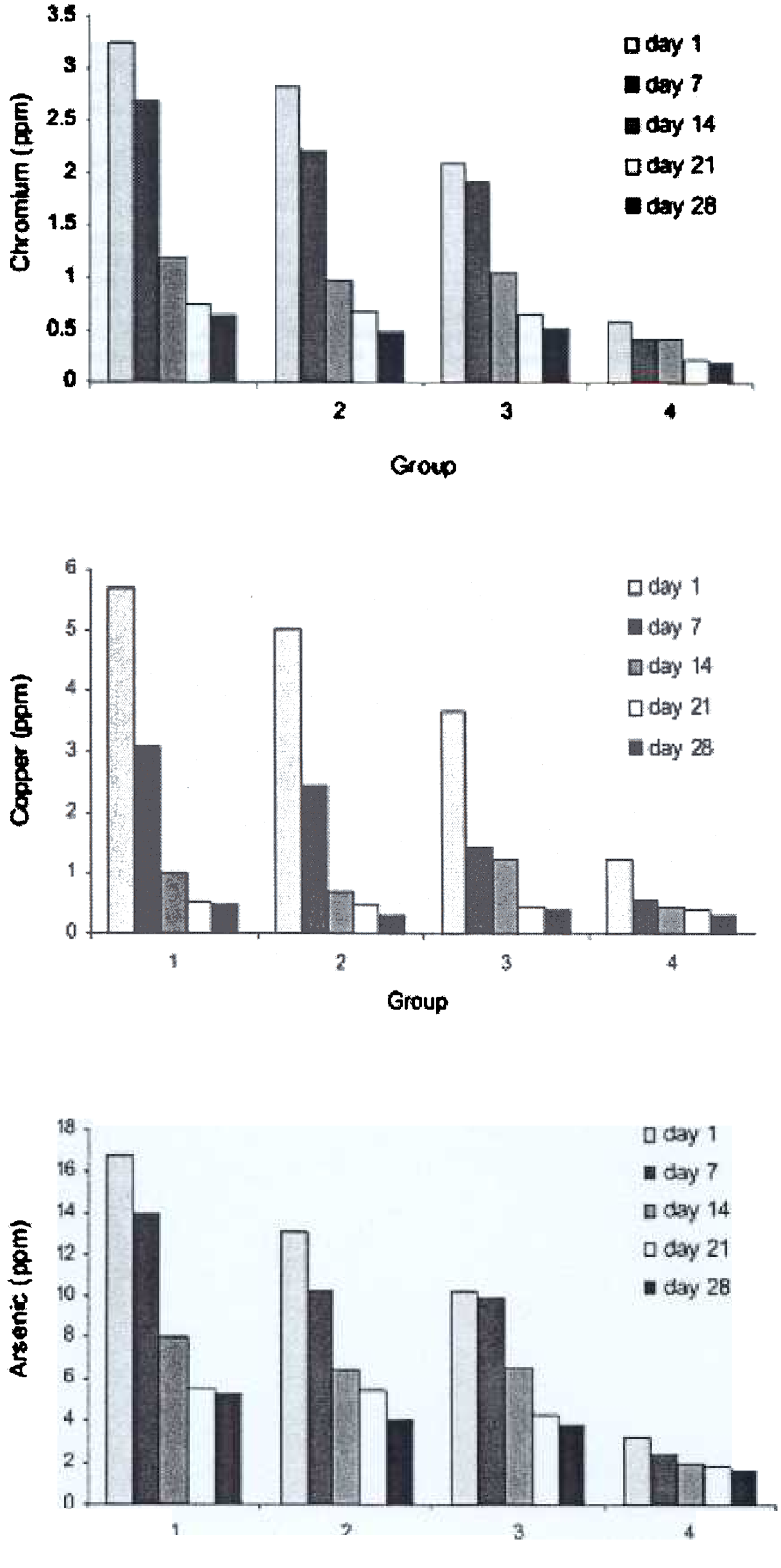

Figure 2. — CCA leaching of flakeboard panels manufactured from five different ratios of recycled CCA-treated wood and virgin untreated southern pine wood.

due to the outer portion of round stock having a higher preservative retention than inner portions after treatment, greater permeability of the outer (sapwood) regions of the stock, and a weathering effect in service. Munson and Kamdem (1998) found that the retention of CCA in particleboard fabricated from CCA-treated wood was higher than that in treated wood. This situation was obersed with group 1 (100% recycled CCA-treated panels).

CCA leaching

The leaching amount of CCA sequentially declined with time for all four groups that contained CCA-treated wood (Fig. 2). After 14 days, the leaching rate tends to be stable at a lower level. The phenomenon was similar to results found by Munson and Kamdem (1998), as well as in agreement with Lebow's finding (1996) that the leaching of CCA-treated wood occurs primarily during the initial stages of placement into service. As expected, the amount of leaching for each group was related to the initial original CCA concentration of each group.

In comparison with the leaching rate of chromium and copper, the leaching rate of arsenic was much greater. This was also reported by Kartal and Clausen (2001). Other scientists (Munson and Kamdem 1998, Kartal and Clausen 2001) found that composite panels made from CCA-treated particles bonded with urea-formaldehyde resin had a relatively higher leaching rate, since this resin is not water resistant. Both of these studies used particleboard and therefore the panels had smaller particle sizes and were more easily leached than the flakeboard used in this study. Moreover, different panel densities were used as well.

Conclusions

This study was designed to determine leaching characteristics of flakeboards made from recycled CCA-treated wood. This is largely due to the outer portion of round stock having a higher preservative retention than inner portions after treatment and greater permeability of the outer (sapwood) regions of the stock. As expected, the CCA contents in flakeboard and the leaching rate were highly related to the percent of CCA-treated wood in panel furnish. PF resin plays a positive role in reducing the leaching of chemicals.

Table 2. — CCA retention of flakeboard panels manufactured from five different ratios of recycled CCA-treated wood and virgin untreated southern pine wood.

Group[a]	Copper oxide	Chromium trioxide	Arsenic pentoxide	Total
		(pcf)		
1	0.11		0.22	0.61
2	0.08		0.16	0.46
3	0.05		0.09	0.26
4	0.03		0.05	0.15
5	0.00		0.00	0.00

[a]Group 1 = 100 percent recycled CCA-treated wood; Group 2 = 75 percent recycled CCA-treated wood, 25 percent virgin wood; Group 3 = 50 percent recycled CCA-treated wood, 50 percent virgin wood; Group 4 = 25 percent recycled CCA-treated wood, 75 percent virgin wood; Group 5 = 100 percent virgin wood.

Table 3. — Analysis of variance of CCA content in guardrail posts.

Source of variation	DF	F-value	p-value
Vertical location (V)	2	1.07	0.3649
Horizontal location (H)	2	6.67	0.0067**[a]
Interaction (V*H)	4	0.61	0.6625

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