

FLAKEBOARDS FROM RECYCLED CCA-TREATED SOUTHERN PINE LUMBER

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ABSTRACT

Large volumes of nonbiodegradable preservative-treated demolition wood must be disposed of in the near and distant future. Landfilling presents long-term problems, and burning is not acceptable, except in certified incinerators, because combustion products contain toxic chemicals. Recycling of treated wood into flakeboards suitable for siding, sheathing, and flooring for high decay-hazard applications may be practicable and a lower cost alternative to disposal in the environment. In this study, flakeboards were made of ring-cut flakes from recycled southern pine lumber that had been treated with chromated copper arsenate (CCA). Flakes were bonded with a liquid phenol-formaldehyde resin. The preservative treatment lowered all property values substantially below those of untreated flakeboards. However, physical and mechanical properties of CCA-treated flakeboards were enhanced by spraying flakes with a 5 percent solids aqueous solution of hydroxymethylated resorcinol primer just before spraying and blending of the resin.

The actual service life of preservative-treated wood, like that of many other building materials, is often shorter than its design service life. Changes in building styles, renovation, deterioration in other parts of structures, obsolescence, and removal of structures for right-of-way are factors that lead to early demolition of still-usable treated wood. Considering the volume of treated wood produced within the last 50 years, disposal problems are potentially great. Industrial statistics (4) show that total production of preservative-treated wood in 1991 was 514.3 million ft.³ (14.57 million m³). Of this total, 398.1 million ft.³ (11.27 million m³) was treated with waterborne preservatives (98% was treated with chromated copper arsenate (CCA)). Because preservative-treated wood is not biodegradable, disposal of CCA-treated wood presents special long-term problems for landfills. Burning is not acceptable either, except in certified incinerators, because combustion products contain arsenical

compounds laced with chromium and copper.

Unwanted preservative-treated demolition wood may be converted from a disposal problem to a valued resource. Recycling of CCA-treated wood into high-valued composite panels may be practicable and a relatively low-cost alternative to disposal into the environment. Nonbiodegradable demolition wood, recycled into flakeboards, might be marketed for siding, sheathing, flooring, and exterior industrial applications suitable for service in high decay-hazard environments.

As early as 1945, scientists at the Forest Products Laboratory (FPL) recognized that chromate-containing preserv-

atives, particularly CCA preservatives, seriously interfered with adhesion of several commercial hot- and cold-press thermosetting adhesives (3). Since then, scientists worldwide have continued to search for causes and solutions for poor adhesion to CCA-treated wood. In their efforts to find ways to manufacture treated flakeboards, Boggio and Gertjansen (2) treated aspen wafers with CCA preservatives to 0.4 pcf (6.4 kg/m³) and then bonded them with powdered novolac and resole phenolic resins. The treated waferboards exceeded the minimum 2,500 psi (1,724 N/cm²) modulus of rupture (MOR) and 450,000 psi (310,275 N/cm²) modulus of elasticity (MOE) in static bending that is required by ANSI A208.1-1979 for Grade 2-M-W waferboard. Less than a 50 percent reduction in MOR occurred after accelerated aging. However, CCA preservative caused internal bond (IB) strength to fall below the required 50 psi (34.5 N/cm²).

A new way to enhance adhesion of CCA-treated wood with phenolic and other thermosetting adhesives is described in a USDA Forest Service patent application (8). Hydroxymethylated resorcinol (HMR) can be used as a coupling agent to physiochemically couple phenol-resorcinol-formaldehyde adhesives to CCA-treated southern pine lumber to form bonds that are extraordinarily resistant to delamination (5). Here we describe an experiment to determine if

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the HMR coupling agent could enhance adhesion of a liquid phenol-formaldehyde (PF) resin to ring-cut flakes from recycled CCA-treated southern pine lumber.

EXPERIMENTAL MATERIALS AND METHODS

FLAKES

Flakes were obtained from CCA-treated and untreated southern pine lumber, nominal 2 by 4 inches (standard 51 by 102 mm), which had been used in bending tests at the FPL. The CCA-treated lumber was treated at FPL to a retention of 0.6 pcf (9.6 kg/m³). The lumber was cut into maxichips, approximately 1 by 1-1/2 inches (25 by 38 mm) in cross section and 3 inches (76 mm) long. The maxichips were flaked with a Pallman ring-flaker so that thicknesses averaged 0.022 inch (0.56 mm). Widths were relatively slender, but random. Lengths varied up to 3 inches (76 mm). A screen analysis of a representative sample of untreated and CCA-treated flakes was obtained. All flakes were dried to 2 to 3 percent moisture content. After flakes were dried, fines and other small particles were screened out by passing flakes over 0.125-inch (3.2-mm) screen openings.

TABLE 1. — Ingredients of the two aqueous solutions.

Ingredients	Solution (parts by weight)	
	(5% solids)	(15% solids)
Water, deionized	90.43	71.29
Resorcinol, crystalline	3.34	10.02
Formaldehyde, 37%	3.79	11.37
Sodium hydroxide, 3 molar	2.44	7.32
Total	100.00	100.00

HMR PRIMER

The HMR primer was prepared by reacting formaldehyde/resorcinol in a 1.5 mole ratio at mildly alkaline conditions. Two aqueous solutions containing either 5 or 15 percent reactive chemical solids were prepared (Table 1).

The mixtures were reacted for 4 hours at room temperature (73°F (22.8°C)) before spraying on flakes in the blender.

ADHESIVES

A liquid, single-stage PF resin that has been used successfully to fabricate commercial southern pine flakeboards was used to bond both CCA-treated and untreated flakeboards. The resin is identified as Georgia-Pacific 3195 by its manufacturer, Georgia-Pacific Corporation. It contained 55 percent resin solids.

EXPERIMENTAL DESIGN

The experiment was factorially arranged into six treatment combinations to show how two levels of flake treatment and three levels of surface primers on flakes would affect selected physical and mechanical properties of flakeboards. Flakeboards were tested for MOE and MOR in static bending, IB, thickness swell (TS), and water absorption (WA). The MOE and MOR were measured before and after accelerated aging (AA). All property values were determined in accordance with procedures in ASTM Method D 1037 (1).

Each of the 6 treatment combinations was replicated 3 times for a total of 18 flakeboards. From each replicate flakeboard, two observations were made for MOR and MOE before and after AA. Two observations of TS and WA and six observations of IB were made for each replicate.

FLAKEBOARD FABRICATION

Flakes were sprayed with either water or one of the two primer solutions to raise

the moisture content of all flakes to equal levels. This determined the amount of HMR solids added to the flakes. Based on the oven-dry weight of the flakes, the 5 percent primer solution added 0.45 percent HMR solids to the flakes. The 15 percent solution added 1.52 percent HMR. Immediately after the primers were applied, the flakes were sprayed with 5 percent phenolic resin solids (based on oven-dry weight of flakes). No adjustments were made in resin content or flakeboard specific gravity to compensate for the slight increase in weight of flakes from CCA and primer solids. Moisture content of the flakes measured after spraying and blending primers and resin averaged 10 percent. The primed and resin-coated flakes were randomly oriented and hand-formed into a 16- by 23-inch (406- by 584-mm) mat. A fully automatic, programmable, particleboard press with an automatic data acquisition system was used to press the flakeboards. Pressure was maintained at a maximum of 809 psi (558 N/cm²) with press temperature at 374°F (190°C) for 8 minutes. Target density was 44.6 pcf (715 kg/m³). Flakeboard thickness averaged 0.48 inch (12.3 mm).

RESULTS AND DISCUSSION

EFFECTS OF CCA TREATMENT

Physical and mechanical properties of CCA-treated and untreated southern pine flakeboards are summarized in Table 2. As the table shows, property values of flakeboards made with unprimed, CCA-treated flakes were substantially lower than those of flakeboards made with unprimed, untreated flakes. These findings are consistent with those of Boggio and Gertjeansen (2). IB strength was lowered 40 percent, whereas MOR and MOE were reduced 29 and 16 percent, respectively. Differences in bending properties were even greater after AA.

TABLE 2. — Physical and mechanical properties of CCA-treated and untreated flakeboards.^a

Flakeboard type	HMR primer solids (%)	Density (pcf) ^b	IB (psi) ^b	MOR			MOE				
				24-hr. TS (%)	24-hr. WA (%)	Before AA (×10 ³ psi)	After AA (×10 ³ psi)	Reduction by AA (%)	Before AA (×10 ³ psi)	After AA (×10 ³ psi)	Reduction by AA (%)
Untreated	0	44.3	107	23.5	69.3	4.853	4.154	14	646.5	513.0	21
	5	45.6	106	26.0	71.2	4.406	3.393	23	601.3	437.7	27
	15	46.2	140	22.7	65.0	5.503	3.794	31	615.9	438.4	29
Treated	0	43.7	64	28.0	77.5	3.435	2.396	30	543.7	362.8	33
	5	44.3	97	23.4	73.2	3.714	2.363	36	536.0	342.5	36
	15	43.7	93	24.0	71.8	4.187	2.661	36	557.2	374.7	33

^a HMR = hydroxymethylated resorcinol; IB = internal bond; TS = thickness swell; WA = water absorption; AA = accelerated aging.

^b pcf = 16.01 kg/m³; psi = 0.6895 N/cm².

Dimensional stability was also adversely affected by the CCA treatment: TS and WA increased 19 and 12 percent, respectively.

Preservative treatment was the major experimental factor leading to lower property values among flakeboards in this experiment. One way that preservative treatment contributed to lower property values, particularly IB strength, was that the chemically fixed CCA preservative itself interfered with adhesion, as explained, at least in part, by Vick and Kuster (7). Using scanning electron microscopy and energy dispersive spectrometry, these authors showed that deposits of insoluble mixtures of chromium, copper, and arsenic were chemically bound to cell walls, and were so pervasive that most opportunities for molecular forces of attraction to act between normally polar wood and adhesive were physically blocked. Using differential scanning calorimetry, Vick and Christiansen (6) also showed that even though free ions of chromium, copper, and arsenic interfered with the normal cure of phenolic resin, once CCA preservative was chemically fixed in the wood, no such interference with adhesive cure occurred.

We suspect that another cause for lower property values of CCA-treated flakeboards was that the treated flakes were less conformable during pressing, which limited opportunities for sound bond formation. The treated flakes appeared to be brittle, with broken edges, whereas the untreated flakes appeared flexible, with cleanly cut edges. A screen analysis supported our observations and indicated that greater percentages of CCA-treated flakes than untreated flakes were in the smaller size classes (< 0.250 in. (< 6.35 mm)). Selected measurements did not reveal any differences in particle thickness. Smaller particle sizes are also known to contribute to lower MOR and MOE, which explains, in part, why these properties were lower in the CCA-treated flakeboards than in the untreated flakeboards. The lower out-of-press densities of treated flakeboards (**Table 2**) also sug-

gest problems with bond formation. Flakeboards with primed and/or CCA-treated flakes actually contained less wood than flakeboards with unprimed, untreated flakes. This replacement of wood with additives is the weight-equivalent of an increase in wood specific gravity, which reduced the compaction ratio and limited bond formation.

EFFECTS OF PRIMERS

Spraying the untreated flakes with the 5 percent solids HMR primer did not improve the properties of flakeboards made with untreated flakes; in fact, small losses occurred among all properties (**Table 2**). However, spraying CCA-treated flakes with the 5 percent primer produced a substantial 52 percent increase in IB strength, thereby eliminating the deficit IB strength found by Boggio and Gertje Jensen (2). TS and WA improved as well, by 16 and 5 percent, respectively. The 5 percent solution did not improve MOR and MOE of the CCA-treated flakeboards.

Increasing the solids content of HMR primers from 5 to 15 percent generally produced only marginal, though reasonably consistent, improvements in properties of untreated and CCA-treated flakeboards. An exception was the increase in IB strength of untreated flakeboards. Such slight improvements in properties do not justify the disproportionate three-fold increase in primer solids content, however.

Generally, property values varied more erratically when primers were sprayed on untreated flakes, as compared with CCA-treated flakes (**Table 2**). We suspect the differences were caused by overpenetration of the resin, particularly into untreated flakes. The HMR primer is highly polar because of its chemical nature. Once the primer was spread on the flake surfaces, all flakes—whether CCA-treated or not treated—were more wettable with highly polar phenolic resin. However, phenolic resin probably penetrated the HMR-primed, hydrophilic untreated flakes more readily and deeper than the HMR-primed hydrophobic CCA-treated flakes, although these

observations were not supported with measurements. Problems of overpenetration of HMR-primed flakes probably could be solved with a powdered phenolic resole resin. Isocyanate resin that reacts with the hydroxyl groups of water and HMR may be a viable alternative.

CONCLUSIONS

Flakeboards made of ring-cut flakes from recycled CCA-treated southern pine lumber and bonded with liquid PF resin had property values that were substantially lower than those of untreated flakeboards. However, a 5 percent solids, aqueous solution of hydroxymethylated resorcinol primer, sprayed on the flakes just before spraying resin, enhanced physical and mechanical properties, particularly IB strength, of the CCA-treated flakeboards.

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