Technical Feature:
Wood Finishes

The effects of CCA-treated wood on the performance of surface finishes

By Alan S. Ross
and William C. Feist

Abstract

CCA-treated wood is widely used in residential and commercial decking — prime substrates for surface finishes. Unfortunately, little information has been published on the effects of CCA-treated wood on surface finishes, and many misconceptions exist.

This study evaluates the performance of transparent and pigmented commercially available coatings over CCA-treated pine and hem-fir compared to controls of untreated wood finished with the same products.

After two years of weathering at sites in Wisconsin and Mississippi, the surface coatings applied to the CCA-treated wood have performed better than those applied to the untreated controls.

A mechanism involving interaction and subsequent stabilization of the surface wood components by the chromium (+6) present in CCA is proposed to explain this enhancement of coating performance.

Introduction

WOOD TREATED with CCA is widely used in outdoor architectural projects such as decks, walkways, gazebos and retaining walls. Although this material was originally marketed as a maintenance-free product, most preservatives manufacturers and end users today recognize the advantages of protecting and beautifying CCA-treated lumber with surface finishes. As a consequence, it frequently becomes a sub-

Technical Feature:

Alan S. Ross is vice president, technical director, Kop-Coat, Inc. William C. Feist is project leader, USDA Forest Products Laboratory. More information: Forest Products Laboratory, One Gifford Pinchot Dr., Madison, Wis. 53705-2398. Phone: (608) 231-9300.

strate for a variety of coatings products.

Unfortunately, little published information is available on the performance of surface finishes over CCA-treated wood[1-5]. This has led to some confusion among preservatives manufacturers, coatings companies, the trade, and consumers as to the compatibility of coatings with this material. Not surprisingly, there are a number of misconceptions about the effects of CCA treatment on coatings performance. This project was undertaken to help clarify some of these issues.

Work carried out at the USDA Forest Products Laboratory (FPL) demonstrated that the application of aqueous solutions of hexavalent chromium (e.g., chromium trioxide) to wood surfaces had an inhibiting effect on the outdoor weathering process and enhanced the life of surface finishes applied over the treated wood[6-7]. Using surface analytical techniques, FPL researchers studied the interaction of the chromium trioxide with the wood components[8] They found that the majority of the chromium on the treated wood was reduced from the (+6) to the (+3) state. In addition, the surface concentration of hydroxyl groups decreased while the hydrocarbon level increased.

These observations are consistent with a mechanism involving an oxidation of the surface wood components by chromium (+6) and subsequent fixation of the reduced chromium to wood carbohydrates and lignin. An idealized reaction representing the reduction/decarboxylation of surface cellulose by chromium (+6) is represented in **Equation 1.**

Consistent with this proposed mechanism, volatile CO_2 was detected as a by-product in the interaction of aqueous chromate with cellulose. In a chromate-cellulose interaction the resulting wood surface would be expected to have an increased hydrophobic character this was borne out by the observation of surface water repellency on wood freshly treated with aqueous chromate solution.

The interactions described above leading to enhanced surface stability have been postulated to explain the chromate-treated wood's observed improvement toward degradation from weathering and ultraviolet light, also resulting in improved coatings performance. Since the widely used preservative treatment CCA-Type C consists of approximately 47 percent chromium trioxide, similar resistance to weathering and ultraviolet light degradation could be proposed as a result of the chromium-wood interactions in CCA-treated lumber. The frequently observed surface water repellency of wood freshly treated with CCA is consistent with the FPL results using chromate treatments.

All of this suggests that surface finishes applied over CCA-treated lumber would

Equation 1

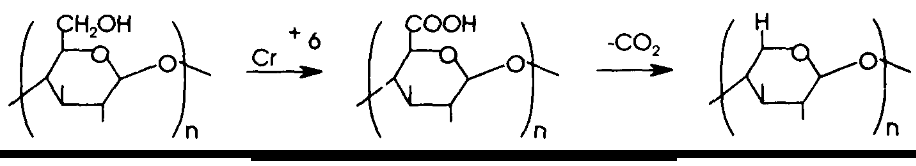

Table 1
Characteristics of Finishes and Pretreatments Used For CCA-Treated Wood

Finish No.	Finish type or pretreatment[a]	Color	Non-volatile content (%)	Weight (lb./gal.)
1.	None (control)			
2.	Laboratory WR	Transparent	18.0	7.1
3.	Commercial WR	Transparent	44.6	7.0
4.	Commercial WRP	Transparent	96.3	7.2
5.	Commercial WR	Transparent	18.9	6.7
6.	Commercial WR	Transparent	4.0	8.4
7.	Commercial semitransparent oil-based stain	Brown	75.6	7.8
8.	Commercial solid-color oil-based stain	Maroon	27.4	8.1
9.	Commercial semitransparent oil-based stain	Brown	33.1	7.2
10.	Commercial semitransparent oil-based stain	Brown	33.0	7.4
11.	Commercial semitransparent oil-based deck stain	Red	22.4	7.1
12.	Commercial varnish stain			
	a. pretreatment	Brown	38.2	7.3
	b. topcoat	Transparent	51.4	7.5
13.	Commercial semitransparent oil-based stain	Maroon	30.5	7.2
14.	Commercial solid-color acrylic latex stain	Brown	36.4	9.9
15.	Commercial paint			
	a. Oil-based primer	White	52.0	9.8
	b. Acrylic latex topcoat	White	53.0	10.9
16.	Commercial paint			
	a. latex primer	White	80.4	11.5
	b. Acrylic latex topcoat	White	59.5	12.1

[a]WR=water repellent; WRP=water-repellent preservative

perform better than those applied over untreated wood of the same species.

The objective of this project was to evaluate the performance of a variety of surface finishes over untreated and CCA-treated wood and to determine the extent of the chromium enhancement effect.

Materials and methods

A number of commercially available clear and pigmented coatings products were applied to untreated and CCA-treated boards of two wood species. These were exposed to exterior weathering at sites in Wisconsin and Mississippi and were evaluated at six-month intervals over a two-year period for coatings performance.

Wood species. The two wood types used in this study were flat-grain southern yellow pine and hem-fir sapwood. These species are commonly treated with CCA and often utilized for outdoor architectural projects. All boards used in this study were firstquality lumber. They were selected for clarity of grain and kick of knots.

Treatment levels. Commercially treated boards of nominal 1-inch by 6-inch by 8-foot dimensions with specified CCA treatment levels of 0.25 and 0.40 pcf were obtained.

Finishes. Surface finishes were obtained commercially and were chosen to represent products commonly used to coat treated wood. They included clear water repellents, semitransparent stains and film-forming solid color stains and paints. Both water-borne and solvent-borne products were utilized.

The composition of the finishes for this study is described in **Table 9. Table 1** outlines some of their physical properties.

Sample preparation. The 1-inch by 6-inch by 8-foot boards were cut into two 4-foot lengths. One 4-foot section from each board was tested in Wisconsin and the other in Mississippi. Each 4-foot board was divided into 8-inch sections by applying strips of aluminum-pigmented varnish so that each board had five 8-inch sections with four inches on each end. The back, sides and 4-inch end sections of each board were left unfinished. All boards were washed with clear water and a stiff bristle brush and dried for 48 hours at ambient conditions. After drying, finishes were applied by brush to the front and edge faces of the boards following manufacturer's recommendations. All finishes were applied under ambient laboratory conditions while the boards were in a horizontal position. The surface coverage, or spreading rate for each product, was calculated by weighing the amount of finish applied to the surface (see **Table 2).**

All finishes were applied as one coat except for Nos. 12, 15 and 16. Finished boards were allowed to dry for seven days indoors before being installed at the test sites.

Exposure conditions. Boards were installed at 45 degrees facing south to ensure maximum sun exposure. This accelerates the weathering process over that of a typical vertical exposure by a time factor of about 2 1/2. Each test series consisted of an uncoated control plus 15 finishes over two wood species (southern yellow pine and hem-fir) at three retentions of CCA — 0 pcf (i.e., untreated), 0.25 pcf and 0.40 pcf. One series was placed on exposure at Madison, Wis., and a duplicate at Saucier, Miss.

Results and discussion

All test specimens were evaluated at the two exposure sites at six-month intervals over a two-year period. Discoloration, surface checking, water repellency and general appearance were evaluated using common coatings-industry performance criteria. The evaluation methods and inspection criteria are listed in **Table 3.**

All evaluations used a 10 (perfect) to 1 (complete failure) scale. A value of 5 indicates the need for refinishing without major surface preparation.

This report focuses on the six-month and two-year accelerated exposure results since they are representative of intermediate and long-term finish performance in service.

For evaluation purposes, the coatings were grouped unto three categories:

1. Transparent water repellents and water-repellent preservatives.
2. Semitransparent stains.
3. Film-forming finishes.

Tables 4 and **5** summarize the performance of the clear water repellent at six months and two years, respectively. **Tables 6** and **7** summarize the semitransparent stain performance at the same intervals.

The film-forming finishes showed no significant weathering effects after six months. The two-year performance summary for these coatings is presented in **Table 8.**

Effects of CCA treatment on performance. — The overall durability and performance of all of the finishes were improved by the effects of the CCA-treated wood. **Figure 1** summarizes the average general appearance scores for all 15 coatings after six months of outdoor exposure. For each species at each exposure site, there is a clear trend toward improved coatings performance over the CCA-created boards.

There does not appear to be a significant difference between the 0.25- and 0.40-pcf levels, but performance of coatings over each of these treatment levels is meaningfully better than that over the untreated wood.

After two years' exposure, performance scores decrease as expected (see **Figure 2).** Again, however, the coatings over CCA-treated boards are significantly outperforming the same materials over untreated boards, and the differences between the 0.25- and 0.40-pcf treatment levels are slight.

Effects of species type on performance. From **Figures 1** and **2** it can be seen that average performance scores for all coatings are slightly higher over hem-fir than they are over southern yellow pine, regardless of exposure site. This trend continues for both levels of CCA treatment as well as the untreated boards.

Effects of exposure site on performance. Not surprisingly, the average performance scores of all coatings are lower in Mississippi than they are in Wisconsin (see **Figures 1** and **2).** It should be noted, however, that the factor most affected in coatings performance in Mississippi is discoloration. This is a result of both greater mildew growth and faster sunlight-induced fading. The location site factor had far less effect on degradation and erosion of the finishes.

Effects of coating type on performance. The film-forming finishes had the highest average performance scores, followed by the semitransparent stains and the clear water repellent/water repellent-preservatives, respectively.

All of the film-forming products (Coating

Table 2
Spreading Rates For Finishes Applied to CCA-Treated Wood[a]

Treatment or Finish No.	Spreading rate, square feet/gal.[b] Southern pine 0	0.25	0.4	Hem-fir 0	0.25	0.4
2.	155	145	165	320	300	290
3.	270	185	305	500	435	425
4.	195	160	225	375	360	345
5.	140	135	165	380	340	340
6.	300	335	420	400	405	440
7.	295	280	290	355	280	340
8.	390	365	365	385	345	365
9.	310	310	295	375	395	365
10.	365	360	365	360	325	340
11.	445	425	410	480	420	490
12. a.	315	360	375	385	330	375
b. (1st coat)	390	435	480	440	370	480
c. (2nd coat)	470	435	580	415	415	515
13.	395	395	385	465	380	480
14.	425	365	450	420	385	410
15. a.	360	345	415	400	375	375
b.	650	635	695	645	615	570
16. a.	350	330	345	370	305	345
b.	390	345	380	470	370	340

[a]Except as indicated, all finishes were applied in one coat.
[b]Values shown for 0, 0.25 and 0.4 PCF CCA treatment levels.

Table 3
Evaluation Methods and Inspection Criteria

Evaluation	Method[a]
Non-volatile content	ASTM[b] D 2369-87
Finish	
Flaking	ASTM D 772-86
Cracking	ASTM D 661-86
Erosion	ASTM D 662-86
Discoloration	Subjective visual assessment similar to ASTM D 3274-82 (mildew)
Substrate	
Cracking	Similar to ASTM D 661-86
Checking	Similar to ASTM D 660-87
General appearance	Subjective visual assessment
Water repellency	Subjective visual assessment after water was splashed on the surface

[a]All evaluations used a 10 (perfect) to 1 (complete failure) scale. A value of 5 indicates the need for refinishing without major surface preparation.
[b]American Society for Testing and Materials

Table 4
Performance of Transparent Water Repellents and Water-Repellent Preservatives on CCA-Treated Wood After Six Months Outdoor Exposure[a]

	Discoloration			Substrate checking/cracking			General appearance		
Finish No.	0	0.25	0.4	0	0.25	0.4	0	0.25	0.4
Southern pine (Wisonsin)									
2.	3.7	7.3	9.0	7.3	6.7	7.7	3.7	7.3	8.3
3.	4.7	7.7	8.0	8.3	7.7	7.3	4.7	7.7	8.0
4.	9.0	8.3	9.0	8.0	7.3	8.0	8.7	7.7	8.7
5.	8.0	9.0	9.0	7.7	7.7	8.0	7.7	9.0	8.7
6.	3.0	8.0	8.0	6.3	7.7	6.3	3.0	8.0	7.3
Southern pine (Mississippi)									
2.	1.0	6.0	4.3	7.0	8.7	7.3	1.0	6.0	4.3
3.	1.0	6.0	4.0	6.0	8.0	7.7	1.0	6.0	4.0
4.	2.7	8.0	5.7	6.0	8.0	7.3	2.7	8.0	5.7
5.	1.7	6.3	4.0	5.7	8.0	7.3	1.7	6.3	4.0
6.	1.0	7.3	6.7	5.0	7.3	7.0	1.0	7.3	6.7
Hem-fir (Wisconsin)									
2.	2.0	9.0	8.3	8.0	8.0	7.7	3.0	9.0	8.0
3.	2.0	6.7	7.3	7.7	8.3	8.3	3.0	6.7	7.3
4.	7.0	8.0	8.3	8.0	8.0	8.7	7.0	8.0	8.3
5.	3.7	8.0	8.3	8.0	8.7	8.0	3.7	8.0	8.3
6.	2.7	8.3	8.3	6.3	7.0	6.7	2.7	8.0	7.7
Hem-fir (Mississippi)									
2.	1.0	6.3	7.3	6.7	8.3	6.7	2.0	6.3	7.0
3.	1.0	6.0	6.3	6.7	8.7	7.0	1.3	6.0	6.7
4.	2.3	7.3	7.7	6.0	7.7	6.7	2.3	7.0	7.3
5.	1.0	5.0	5.7	7.0	8.0	7.0	1.3	5.0	5.7
6.	1.0	6.7	7.7	7.3	6.0	5.0	1.7	6.0	5.7

[a]Values shown are for preservative retentions of 0, 0.25 and 0.4 PCF. Average of 3 replicates.

Nos. 8, 10, 14, 15, 16) were high-quality formulations and were applied following correct application techniques. This resulted m excellent performance over CCA-treated wood after two years of exposure at 45 degrees facing south. Ultimately, the problem with these finishes would be in their mode of failure.

Most paints, being film-forming coatings, fail by cracking, blistering and peeling. Before the surface can be recoated, the remnants of these finishes must first be removed. In addition, while the film-forming products performed well on a 45-degree exposure, they typically do not last as long on a horizontal exposure such as a decking surface. For these reasons, film-forming coatings are generally recommended only for vertically exposed surfaces such as siding and trim.

The semitransparent finishes (CoatingNos. 7, 9, 10,11, 13) were not as consistent as the film formers in their performance (see **Table 7.)** All had enhanced effectiveness over CCA-treated wood, but with varying degrees of success.

Table 5
Performance of Transparent Water Repellents and Water-Repellent Preservatives on CCA-Treated Wood After Two Years of Outdoor Exposure[a]

	Discoloration			Substrate checking/cracking			Water repellency			General appearance		
Finish No.	0	0.25	0.4	0	0.25	0.4	0	0.25	0.4	0	0.25	0.4
Southern pine (Wisconsin)												
2.	1.0	3.7	3.0	4.0	4.7	5.7	2.3	5.0	6.0	1.0	3.7	3.0
3.	1.0	3.7	3.3	4.7	5.0	5.7	6.0	8.7	7.0	1.0	3.3	4.0
4.	1.3	3.7	4.0	5.0	4.3	5.7	5.0	7.0	7.0	1.3	3.3	4.0
5.	1.0	3.3	3.0	5.0	5.3	5.3	1.0	2.3	2.3	1.0	3.3	3.0
6.	1.0	4.0	4.7	4.0	5.3	3.7	1.0	1.0	1.0	1.0	4.0	4.3
Southern pine (Mississippi)												
2.	1.0	2.3	2.3	4.3	6.3	5.7	1.0	7.0	5.0	1.0	2.3	2.3
3.	1.0	2.3	2.3	5.0	7.3	5.7	5.0	8.7	8.0	1.0	2.3	2.3
4.	2.0	3.7	3.0	4.0	7.0	5.3	1.0	5.7	5.0	2.0	3.7	3.3
5.	1.0	3.3	2.3	3.7	6.7	5.3	1.0	4.7	3.7	1.0	3.3	2.3
6.	1.0	4.0	4.0	3.0	5.0	4.0	1.0	1.0	1.0	1.0	4.0	4.0
Hem-fir (Wisconsin)												
2.	1.0	4.3	4.7	3.3	4.3	5.3	1.0	7.0	6.0	1.3	4.0	4.3
3.	1.0	4.3	4.7	3.3	4.3	5.3	5.0	7.0	8.0	1.3	4.0	4.3
4.	1.0	4.3	4.7	4.0	4.3	5.3	2.3	8.0	5.0	1.3	4.0	4.3
5.	1.0	4.3	4.7	3.7	4.3	5.3	1.0	3.7	3.7	1.3	4.0	4.3
6.	1.0	4.3	4.7	3.3	3.7	4.0	1.0	1.0	1.0	1.3	3.7	3.7
Hem-fir (Mississippi)												
2.	1.0	2.0	4.3	4.3	5.3	3.7	1.0	1.0	2.3	1.0	2.7	3.7
3.	1.0	2.3	3.7	4.7	5.7	4.3	1.0	3.7	5.0	1.0	3.0	3.7
4.	1.0	3.7	4.0	4.7	5.7	4.3	1.0	3.7	7.0	1.0	4.3	4.0
5.	1.0	2.7	3.7	5.0	5.0	4.3	1.0	3.7	5.0	1.0	3.3	3.7
6.	1.0	3.7	4.0	4.7	4.0	3.0	1.0	1.0	1.0	1.0	3.7	3.3

[a]Values shown are for preservative retentions of 0, 0.25, and 0.4 PCF. Average of 3 replicates.

For example, at the six-month evaluation (see **Table 6),** product 9 had general appearance scores in the 3-4 range. Note that product 11's performance was particularly enhanced over the CCA-treated wood compared to the untreated boards. Thus, for the semitransparent stains, formulation was an important factor in overall performance. After two years, most of these products were close to failure.

Due to the lack of UV-blocking pigments, the transparent water repellents and water-repellent preservatives had the lowest performance scores of the three coatings groups. At six months (see **Table 4),** performance was fairly consistent and again was enhanced by the CCA-treated substrate. Discoloration was greater in Mississippi, with mildew growth being far more pronounced on the coatings applied to the untreated wood. After two years (see **Table 5),** virtually all of the transparent products had totally failed over the untreated wood and most were close to failure even over CCA-

Table 6
Performance of Semitransparent Stains on CCA-Treated Wood After Six Months Outdoor Exposure[a]

	Erosion			Substrate checking/cracking			General appearance		
Finish No.	0	0.25	0.4	0	0.25	0.4	0	0.25	0.4
Southern pine (Wisconsin)									
7.	7.7	9.0	8.3	7.0	9.3	8.0	7.3	9.0	7.7
9.	2.7	2.7	2.7	6.3	8.0	7.7	3.7	4.0	2.7
10.	9.3	9.3	9.0	5.7	9.0	7.7	8.0	8.7	8.7
11.	4.0	7.3	6.7	6.3	9.3	7.7	4.3	6.7	7.0
13.	8.0	7.3	8.3	9.0	7.7	7.3	7.3	7.3	8.0
Southern pine (Mississippi)									
7.	9.0	8.0	7.7	6.7	8.7	6.7	5.3	7.0	6.0
9.	5.0	3.0	2.0	6.7	7.7	6.7	3.0	4.0	3.0
10.	9.0	9.0	8.3	7.3	8.3	6.7	8.0	8.7	8.0
11.	7.0	7.0	7.3	6.7	7.7	6.0	3.7	6.7	6.7
13.	7.3	8.0	7.7	7.3	8.3	8.7	7.3	7.3	7.7
Hem-fir (Wisconsin)									
7.	8.3	9.0	9.0	8.7	9.7	9.0	8.3	9.0	9.0
9.	6.3	4.0	5.3	9.3	8.3	8.7	6.3	5.0	5.3
10.	9.3	9.0	9.3	9.3	8.0	9.0	9.0	8.3	8.7
11.	7.0	8.0	8.0	7.7	7.0	7.0	6.7	8.0	7.3
13.	7.0	8.7	8.3	9.7	6.7	6.3	7.0	7.0	7.3
Hem-fir (Mississippi)									
7.	8.7	9.0	9.0	8.3	7.7	8.0	6.3	8.0	7.7
9.	5.0	6.3	6.7	8.0	7.3	6.7	5.0	6.3	6.0
10.	9.0	9.0	9.0	8.0	7.3	7.3	7.7	8.3	8.0
11.	7.3	7.7	7.7	8.0	6.0	5.7	4.7	6.7	6.7
13.	6.7	7.0	7.7	9.0	7.7	8.0	5.3	6.7	6.7

[a]Values shown are for preservative retentions of 0, 0.25 and 0.4 PCF. Average of 3 replicates.

treated boards. Interestingly, some of the finishes still exhibited surface water repellency after two years of exposure in Mississippi. Again, the CCA-treated substrates generally enhanced this effect.

One advantage of the transparent and semitransparent finishes in this study is that they failed by erosion rather than by cracking and peeling, as would be expected for the film-forming opaque finishes. This means that subsequent application of a fresh coating over the non-film-formers could be accomplished without an extraordinary amount of surface preparation — an advantage for many end users.

Conclusions

The CCA treatment was shown to have a positive effect on the performances of all finishes in the study. Little difference was noted between the 0.25-pcf and 0.40-pcf retention levels. Coatings performance was generally better over hem-fir than over south-

Table 7
Performance of Semitransparent Stains on CCA-Treated Wood After Six Months Outdoor Exposure

	Erosion			Substrate checking/cracking			General appearance		
Finish No.	0	0.25	0.4	0	0.25	0.4	0	0.25	0.4
				Southern pine (Wisconsin)					
7.	6.3	7.0	6.3	4.3	7.7	6.3	5.0	7.0	6.0
9.	1.0	2.0	2.0	5.0	6.7	5.0	1.0	2.0	2.0
10.	5.3	6.3	5.7	6.0	6.7	6.0	5.0	6.0	5.7
11.	2.0	3.7	3.7	4.3	6.3	5.0	2.0	4.0	3.7
13.	3.0	4.0	4.0	5.7	7.0	5.3	2.0	4.3	4.3
				Southern pine (Mississippi)					
7.	5.3	7.0	7.7	4.0	7.3	5.0	3.3	5.7	5.3
9.	2.0	3.0	3.0	3.7	6.0	3.7	2.3	3.7	2.7
10.	6.7	6.7	6.7	4.0	5.7	4.3	5.0	6.3	6.0
11.	2.7	4.7	5.7	3.7	5.7	3.7	2.7	5.0	3.3
13.	4.3	4.7	5.0	5.0	5.7	6.0	4.3	4.3	5.0
				Hem-fir (Wisconsin)					
7.	8.3	8.0	8.0	6.3	6.0	5.0	7.3	6.7	7.0
9.	2.3	2.0	2.7	5.0	4.0	5.3	2.0	2.0	2.3
10.	6.3	6.7	6.3	6.0	3.7	4.3	5.0	4.7	4.7
11.	2.3	4.0	5.0	5.3	3.7	4.0	2.0	3.7	3.7
13.	3.0	4.0	3.0	7.7	4.7	5.3	2.3	4.3	3.0
				Hem-fir (Mississippi)					
7.	5.0	6.7	6.3	6.0	4.0	5.0	4.0	4.3	4.3
9.	3.3	3.3	3.7	5.3	4.0	2.7	2.3	3.3	3.3
10.	6.7	7.0	6.3	6.0	4.3	3.3	6.7	6.0	5.3
11.	3.3	4.3	4.3	5.0	4.0	3.3	3.3	4.0	3.7
13.	4.0	5.7	4.0	6.7	4.7	5.0	3.3	5.0	3.7

[a]Values shown are for preservative retentions of 0, 0.25 and 0.4 PCF. Average of 3 replicates.

ern yellow pine, regardless of treatment levels. Failures occurred more rapidly in Mississippi than they did in Wisconsin, particularly with regard to surface discoloration. The differences in finish degradation were less pronounced between the two exposure locations.

Within the coatings groups, the overall durability and appearance was reflected by the order Fully pigmented (film-forming paints and stains) > lightly pigmented (semitransparent stains) > unpigmented (transparent water repellents and water repellent preservatives).

This study has demonstrated that CCA-treated wood is not only compatible with a variety of surface finishes, but the effects of the treatment enhance the performance life of those finishes.

Further work is under way to evaluate the performances of some of the newer VOC-compliant coating formulations over CCA-treated and untreated wood. Many of these new-generation products are water-borne systems. Updates will be provided in future communications.

Table 8
Performance of Film-Forming Coatings on CCA-Treated Wood After Two Years Outdoor Exposure[a]

Finish No.	Discoloration			Substrate checking/cracking			Finish Failure			General appearance		
	0	0.25	0.4	0	0.25	0.4	0	0.25	0.4	0	0.25	0.4
	Southern pine (Wisconsin)											
8.	6.7	7.7	7.0	5.3	7.3	5.7	7.3	8.0	8.0	6.0	7.7	7.0
12.	7.3	7.0	7.7	6.3	8.7	7.3	7.3	7.0	7.7	5.7	6.7	6.7
14.	5.7	7.7	7.3	5.7	6.3	5.3	6.3	7.7	7.3	5.7	6.7	6.7
15.	6.3	8.7	8.3	9.0	9.3	9.0	9.0	9.0	9.0	8.3	9.0	9.0
16.	8.3	9.0	9.0	9.3	9.3	9.0	9.0	9.3	9.0	8.3	9.0	9.0
	Southern pine (Mississippi)											
8.	3.3	6.0	5.7	3.7	6.0	4.0	6.7	8.0	7.7	4.7	6.7	5.7
12.	4.7	5.7	7.3	6.0	7.0	8.0	5.7	6.0	8.3	4.7	5.7	7.3
14.	5.3	8.0	7.7	4.3	6.0	5.3	8.0	7.3	8.0	5.0	7.3	7.0
15.	4.0	6.7	5.7	8.7	9.0	8.3	9.0	9.0	9.0	4.0	6.7	5.7
16.	5.0	7.0	5.7	7.3	9.0	8.7	8.3	9.0	9.0	5.0	7.7	5.7
	Hem-fir (Wisconsin)											
8.	7.3	8.7	7.7	6.3	4.0	4.7	8.3	9.0	9.0	7.0	6.3	6.7
12.	8.0	8.3	8.3	9.7	7.3	8.3	9.3	9.0	8.3	8.0	8.0	8.3
14.	5.7	7.7	6.7	7.0	4.0	5.3	6.7	8.0	7.3	5.7	5.3	5.7
15.	6.3	8.0	8.3	9.3	9.0	9.0	9.7	9.0	9.3	6.7	8.0	8.3
16.	8.3	8.7	9.0	8.7	8.7	9.0	9.7	9.0	9.3	8.3	8.7	9.0
	Hem-fir (Mississippi)											
8.	5.7	7.7	7.0	5.7	3.0	3.7	7.0	6.3	7.0	6.0	5.0	5.3
12.	5.7	7.0	7.0	8.0	7.7	6.3	8.7	8.7	7.7	5.7	7.7	6.7
14.	4.7	7.7	7.3	6.3	5.3	4.7	7.3	7.7	7.0	4.7	7.0	6.0
15.	3.0	7.0	7.0	8.3	9.3	8.3	9.0	9.3	8.7	3.0	7.0	7.0
16.	4.3	8.3	7.3	9.3	8.7	8.3	9.0	9.0	8.7	4.3	8.3	7.3

[a]Values shown are for preservative retentions of 0, 0.25 and 0.4 PCF. Average of 3 replicates.

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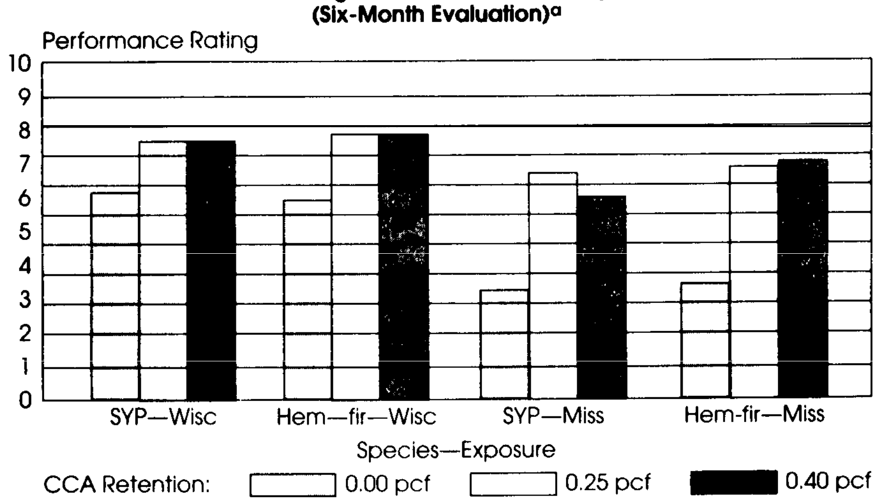
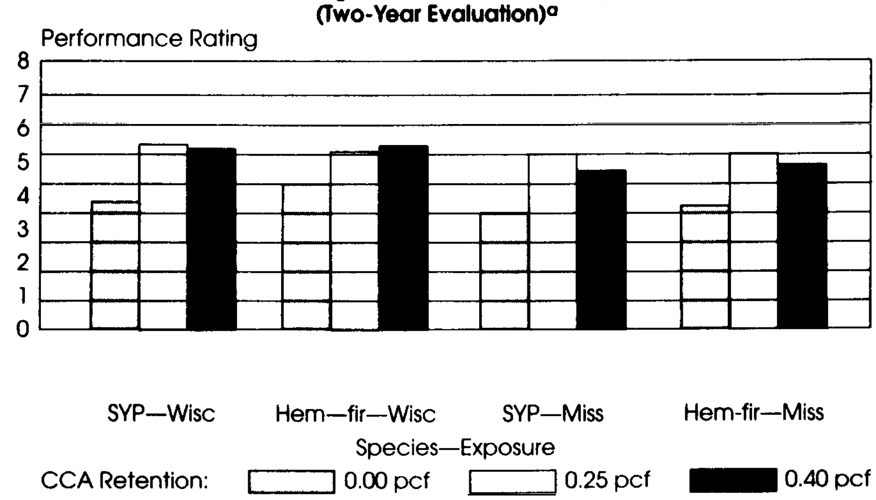
Figure 1
Coatings Performance Summary
(Six-Month Evaluation)[a]



[a] Values shown are average general appearance ratings for all 15 coatings.

Figure 2
Coatings Performance Summary
(Two-Year Evaluation)[a]



[a] Values shown are average general appearance ratings for all 15 coatings.

Table 9
Finishes For CCA Study

Number	Description
1.	Control (no finish)
2.	Laboratory water repellent. Composition: 3% paraffin wax, 5% pine oil, 20% exterior urethane varnish, 72% mineral spirits.
3.	Commercial water repellent oil stabilizer for CCA pressure-treated wood. Composition: contains no pesticides; contains petroleum distillates.
4.	Commercial water-repellent wood preservative. Composition: active ingredient, 3-iodo-2-propynyl butyl carbamate 0.5%; inert ingredients: 99.5%; specially formulated for wood substrates above ground level.
5.	Commercial water repellent. Composition: pigment 0%; contains petroleum distillates; For treated and untreated wood.
6.	Commercial water repellent. A water-borne penetrating stabilizing treatment for new exterior wood.
7.	Commercial semitransparent oil-based natural stain finish; manufactured according to recommended formulas of the U.S. Forest Products Laboratory, Madison, Wis.
8.	Commercial solid-color oil-based stain and water repellent. Composition: contains petroleum distillates.
9.	Commercial semitransparent linseed oil-based stain and wood preservative. Composition: active ingredients: Bis (tributyltin) oxide 0.50%, Folpet (N-((trichloromethyl) thio) phthalimide) 0.50%; inert ingredients: 99.0%.
10.	Commercial semitransparent oil-based stain specially formulated for pressure-treated wood. Composition: alkyd resin-base stain, water repellent, mildew resistant.
11.	Commercial semitransparent wood stain specially formulated for pressure-treated wood decks. Composition: pigment 4.5%; water repellent formula; contains petroleum distillates; can be used for untreated wood.
12A.	Commercial translucent wood finish (varnish stain) for exterior wood protection. Composition: contains petroleum distillate solvents, transparent iron oxides and 0.30% Bis (tributyltin) oxide.
12B.	Commercial translucent topcoat (varnish stain) for exterior wood protection over finish 12A. Composition: Contains petroleum distillate solvents, transparent iron oxides and 0.50% Bis (tributytin) oxide: UV light-resistant.
13.	Commercial semitransparent oil-based stain and water repellent. Composition: Contains petroleum distillates.
14.	Commercial heavy bodied (solid-color) latex exterior stain. Composition: Pigment 20.5%, vehicle 79.5% (acrylic resin 15.5%, water and dispersants 84.5%).
15A.	Commercial acrylic latex wood primer. Composition: Pigment 20% (titanium dioxide (Type IV) 16%, silica 4%); vehicle 80% (acrylic resin 27%, additives 3%, water 46%, ethylene glycol 4%).

Continued on page 54

Table 9
Finishes For CCA Study

(continued from page 53)

Number	Description
15B.	Commercial acrylic latex flat house and trim paint. Composition: Pigment 29%; (titanium dioxide (Type IV) 14%, titanium dioxide (Type I) 3%, silicates 7%, mica 5%, tinting colors (trace)); vehicle 71% (acrylic resin 19%, additives 2%, water 48%, ethylene glycol 2%).
16A.	Commercial alkyd exterior wood primer, Composition: Pigment 49% (titanium dioxide (Type 3) 16%, silicates 25%, silica 4%, mica 4%); vehicle 51%: (alkyd resin modified with linolenic, linoleic, oleic and stearic acids 27%); 2,4,5,6- tetrachloro-isophthalonitrile 1%; mineral spirits 23%.
16B.	Commercial acrylic latex flat house and trim paint. Composition: Pigment 34%; (titanium dioxide (Type III) 25%, zinc oxide 1%, silicates 8%); vehicle 66%; (acrylic/polyester resin 17%; 2-n-octyl-4-isothiasolin-3-one 1%, soya alkyd 2%, water 46%).

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