Solids Cure Deck Stains: Trends, Substrates, and Formulation Study

by Greg Monaghan
Rohn and Haas Company

The changing decking market offers new products to consumers and new challenges to coating manufacturers. The voluntary phase out of CA€™s CCA-treated wood for residential applications at the end of 2003 opened up the decking market in new wood treatments as well as composite decking materials usually composed of wood fibers and recycled plastics. Solid color stains which are to coat these substrates need good adhesion on weathered and unweathered composite substrates, durability resistance, easy brushing, and exterior durability. In addition, government regulations are forcing solid color stains to have lower VOC levels and many stains are now formulated from bases with high loadings of universal colorants. Background information on new decking substrates will be presented in this article along with data on performance of acrylic binders in VOC-compliant solid color stain formulations for these substrates.

INTRODUCTION

Despite a slowing of new housing starts, growth in the use of decking materials is expected to remain strong. As existing decks reach the end of their useful lifespan, homeowners will be purchasing decking materials to repair and replace them. The use of wood plastic composites is expected to grow and new types of treated wood are now being sold to replace the chromated copper arsenate (CCA) decking. Formulating coatings which can be used on these wood plastic composite substrates, on weathered CCA decking, and on new types of wood treatments can present significant challenges to the coatings manufacturers.

CCA AND NEW WOOD PRESERVATIVES

Chromated copper arsenate wood preservatives were withdrawn from the market for residential use in 2003. The remediation of existing CCA-treated decks may present an opportunity to the coatings manufacturer as well as a challenge. Studies have found that coating the decks can significantly reduce leaching of chromium and arsenic from the CCA wood and solid color or semitransparent deck coatings may be used by homeowners who are concerned about CCA exposure. However, a significant problem with applying exposure in this way is that coating old, weathered CCA decks can lead to rapid cracking and flaking of many of the currently commercially available solid color deck stains. The current EPA coating recommendation is to reduce possible exposure to the chemicals in CCA decks by using semitransparent deck stains because the surface preparation to remove a cracked or flaking deck coating (such as sanding or pressure washing) can increase exposure to arsenic. Flexible solid color deck stains which can resist cracking on these weathered decks but which also are hard enough to resist dirt pick up and resist abrasion under foot traffic are needed. Since even the most flexible solid color stains will eventually fail on severely weathered decking, the importance of regular maintenance of solid color deck stains will need to be stressed.

Several types of CCA replacement wood treatments have been introduced. The most widely used replacement for CCA treatments are now ACP (aluminum copper quatamminum compound), copper boron azole (CBA) and copper azole (CA-B) treatments. These new treatments have a somewhat different performance profile than the CCA treatment although these differences may be more apparent in the coatings chemist than a homeowner. The uncoated wood with the new treatments or treated wood with a semitransparent stain might be expected to be more resistant to the new, less resistant to the new, more resistant to the old. Since acid or baking soda can be used as an insecticide, the copper azole treatment (CA-B) which does not contain but has higher levels of copper and triazole. CA-B is 96% copper and uses 4% organic triazole as the co-bicid and is usually used in an ethanamine carrier. Some special precautions are needed in constructing decks using lumber with these surface treatments. Wood treated with these preservatives can cause more corrosion than CCA-treated lumber, so stainless steel or hot dipped galvanized fasteners are typically recommended. The treated wood should also not be used to contact with aluminum and a 1/4 inch space between treated boards and aluminum siding is usually recommended.

Both types of preservative use copper to protect wood, but with water repellency. If the wood is treated with water repellent, the manufacturers recommend weathering for 30-60 days before applying an oil-based stain or weathering for 6-8 months before applying an aqueous stain. In our laboratory testing, we have found that many commercial water-based solid color stains have good adhesion to unweathered wax-treated lum-
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Several types of CCA replacement wood treatments have been introduced. The most widely used replacement for CCA treatment is a non-CCA (alkaline copper quaternary compound), copper boron azole (CBA) and copper azole (CA-B) treatments. These new wood treatments have a somewhat different performance profile than the CCA treatment although these differences may be more apparent to the coatings chemist than to a homeowner. The uncoated wood with the new treatments or treated wood with a semitransparent stain might be expected to be more visible than CCA treated wood since the chromium in CCA is a free radical quencher and crosslinking agent for lignin.3 The CCA replacements are also less resistant to mildew than CCA and mildewcides are sometimes incorporated into the new treatment formulations to prevent mildew growth as the boards are seasoned. Finally, higher use levels of the new treatments are required to give performance equal to the CCA treatment. The higher concentrations of copper can lead to more discoloration of coatings if the decking has not been adequately seasoned before being painted.

ACQ is composed of 56% copper compound and 33% of a quaternary ammonium compound, diethyl(dimethylammoniumchloride) (DDAC).4 Both the copper and the quaternary ammonium components are effective against wood destroying fungi and insects which ingest the wood. Insects which do not ingest the wood such as carpenter ants or boyer beetles are not affected by ACQ treatment.5 Although the copper in ACQ is broadly effective against most fungi, it is not effective against all types of fungi so it cannot be used as the sole preservative. The use of the DDAC as a cooxidant along with the copper gives ACQ-treated wood very good resistance to fungi. The most commonly used forms of ACQ uses ethanolamine as the carrier solution (ACQ-D). Recent research indicates that the ACQ-D is relatively leach resistant because of chemical fixation reactions within the wood which occur rapidly—within hours—after treatment.6 The fixation reaction for ACQ-D begins in part with the rapid formation of insoluble copper–amine–wood complexes and on aging gives insoluble, possibly cross-linked wood. ACQ-R is in another form of the preservative which uses ammonium as the carrier instead of ethanolamine. Ammonia helps the ACQ-B to penetrate into more difficult-to-treat woods like Douglas Fir and the ACQ-B is used primarily on the West Coast where these species are more commonly used as building materials. ACQ-B does not undergo the same rapid fixation reactions as ACQ-D and the wood needs to be kiln dried or seasoned adequately in outdoor exposure to be sure that the fixation has occurred.7

CBA or copper boron azole preservatives are typically composed of 49% copper, 49% boric acid and 2% of an organic triazole such as trichloroisocyanuric or propiconazole. As in the ACQ, the copper in CBA is effective against most fungi and insects but it is not effective against fungicide. Boric acid is effective against insects and fungi but it is water soluble and is subject to leaching from the wood. Trichloroisocyanuric is an effective fungicide and is leach-resistant in the wood but it is objectionable as an insecticide is still uncertain.8 Propiconazole is also an effective fungicide but it is considered ineffective as an insecticide.9 CBA treatment is now being generally supplanted by the recently approved Copper Azole treatment (CA-B) which does not have boron and has higher levels of copper and triazole. CA-B is 56% copper and uses 4% organic triazole as the cooxidant and is usually used in an ethanolamine carrier.10,11

Some special precautions are needed in constructing decks using lumber with these surface treatments. Wood treated with these preservatives can cause more corrosion than CCA-treated lumber.12 so stainless steel or hot-dipped galvanized fasteners are typically recommended. The treated woods should also not to be used to contact with aluminum and a 1/8" space between treated boards and aluminum siding is usually recommended.

Both types of preservative can be made with added wax for water repellency. If the wood is treated with water repellent, the manufacturers recommend weathering for 30–60 days before applying an oil-based stain or weathering for six months before applying an aqueous stains. In our laboratory testing, we have found that most commercial water based solid color stains have good adhesion to unweathered wax-treated lum-
ber and that the six month weathering may not be necessary.

Freshly treated ACQ and CBA lumber is often a grayish brown color and will turn to a light tan color after exposure to sunlight. Both types of wood treatment can be painted or stained as long as the boards have a chance to weather and become seasoned. If they are painted or stained before the wood is seasoned, the preservatives may cause colors or stains. Some laboratory screening was done to find laies stains which might block or prevent this discoloration but no effective stain blocking method was found. The best way found to avoid this discoloration is to allow the treated wood to weather for one month before painting or staining.

**COMPOSITE DECKING**

There are many types of wood like plastic composite (WPC) decking now available. The composite boards are about two times as expensive as treated wood. ACQ-treated yellow pine is $56.75 for a 12-ft board while most composite decking starts at $119.00-$200.00 for a 12-ft board. For a finished deck surface, many of the less expensive wood plastic composites are similar in price to cedar decking or exotic hardwoods such as IPE.

There are usually several products with different finishes available from each composite decking manufacturer. Most of the boards are made with recycled plastic and wood fiber or other fibers. Although most composite manufactures market their products as being relatively maintenance free, there are several reasons why people may want to paint them. A homeowner who wants the color of the deck to the color of the trim of his house may paint new composite decking. Many composite boards also will have a significant color fade to gray upon exposure to UV light and may need to be repainted to restore the original color. Finally, wear patterns or staining of the weathered composite decking may make coating them desirable.

The decision to paint a composite deck can be easily stained by grease or oils from barbecue grills. These stains are not easily removed and sanding them off is not usually recommended since it can remove the embossed wood grain. Different composite manufacturers have different recommendations for coating their products. Most recommend weathering the panels for two to three months before painting them, but a few manufacturers specifically recommend that their products not be coated at all.

Composite substrates are a more stable substrate than wood decking, and do not have the same tendency to crack or pressure. They offer fewer challenges for the coatings manufacturer. The trend towards an embossed wood grain on the composite board may mean that a coating will need to be harder and more abrasion resistant in order to avoid both wear on the raised areas of the embossing and excessive dirt pick up in the low areas. Adhesion to the extrusion plastics used in the composite boards can also be a significant problem, depending on the ratios of wood fiber and polymer used, as well as the use of additives in the extrusion board manufacture. The recycled feedstocks used in the boards can vary depending on the availability of the source materials, so there is a potential for significant variation when the different extrusion plants are used.

Another potential problem with many types of composite decks is tannin staining. The wood fibers used in some types can come from oak or other high tannin species, so there can be a significant discoloration of solid color stains. Finally, weathered composite boards may include chalk which can reduce adhesion of deck coatings.

Although there are new deck coatings on the market designed specifically for composite decking, a deck coating can be sold more widely if it can be used for both composite and wood decks. To be used for both substrates, the solid color stain needs to have excellent crack resistance on weathered wood decks as well as good abrasion resistance and good dirt pick-up resistance on both new and weathered composite decking.

**TESTING PROCEDURES**

Wet adhesion tests are designed to measure paint’s ability to retain its grip in severe atmospheric conditions. These tests are commonly employed to evaluate wet adhesion. Both bohn and haas chemists also rely heavily on the so-called "force to peel," or "weight pull," test for this purpose. Chemos finds this method particularly appealing because it provides a quantitative measure of wet adhesion that is less subjective than crosshatch and knife peel tests. As in the case of other wet adhesion procedures, it is typically conducted on a variety of substrates including split glass aluminum and chalky oil, latex paints, and bare wood.

In the force to peel wet adhesion test, the investigator applies 2.5 g of a test paint to a 1/16 in. x 6 in. section of the substrate with a 1 in. brush. As soon as this process is completed, the investigator centers a 1/16 in. x 9 in. strip of cheesecloth directly over the coated section of the substrate so that 1/16 in. of the strip extends beyond the upper and lower edges of the fresh paint. While embedding the cheesecloth in the first coat of paint, the investigator covers the cheesecloth with 7.5 additional layers of paint. The painted panel is then cured at a controlled temperature and humidity after which two parallel lines are inscribed through the cheesecloth and onto the substrate (1/4 in. from each side border along the entire length of the strip). The two wet lines create a 1 in. strip in the cheesecloth. The panel is then placed in a fog box for 30 rain or more depending on the severity of the test. When conditioning is complete, the box is removed from the fog box and at

**Table 1**

<table>
<thead>
<tr>
<th>Acrylic</th>
<th>Solvent</th>
<th>Waterborne</th>
<th>Solvent-Borne</th>
<th>Acrylic/Alcohol Coatings</th>
<th>Acrylic/Alcohol Coatings</th>
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<tr>
<td>VOC</td>
<td>10-20</td>
<td>20-40</td>
<td>50-80</td>
<td>100-200</td>
<td>50-80</td>
<td>100-200</td>
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**Table 2**

<table>
<thead>
<tr>
<th>Deep Base Solid (Cure Spec)</th>
<th>11 in. Colarant</th>
<th>Waterborne Contact Coatings</th>
<th>4 in. Colarant</th>
<th>Acrylic/Alcohol Coatings</th>
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</tr>
</tbody>
</table>

**Wet adhesion by Force to Peel Method (grams to failure)**

Composites 1 300 350 400 450 500
Composites 2 300 350 400 450 500
Composites 3 300 350 400 450 500
Composites 4 300 350 400 450 500

**TEST RESULTS**

An experimental 100 VOC solid color stain neutral bonding capability was prepared. This stain had a PVC of 26.3% and a volume solids of 28.4%. It was thinned with Acrysol RM-2002NP and Natrosol 255 HRB and

**Technology Today**

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20 contained 20 lb of zinc oxide. These neutral bases were tinted with 15 vol% of universal colorants to a solid color. Several binders were evaluated including a conventional exterior acrylic and a new ambient temperature crosslinking acrylic which has excellent grain crack resistance and good adhesion to a variety of substrates. Six commercial solid color stain controls ranging from 100 to 250 VOC were also tested. The commercial controls were also neutral bases and were tinted with the same levels of universal colorants as the experimental paints.

On untreated treated wood, solid color stains had good adhesion. On three-month weathered treated wood, however, there was a significant increase in the adhesion (see Table 1). The ambient temperature crosslinking acrylic had very good adhesion and was equal to the best of the commercial controls. The effect of the binder chemistry can be seen by comparing the conventional acrylic to the ambient temperature crosslinking acrylic in the same formulation. The stain based on the conventional acrylic had lower wet adhesion to the weathered treated wood than the stain based on the ambient temperature crosslinking acrylic polyol.

On composite decking, the adhesion was different than on treated wood. The weathered composite deck was the easiest to adhere to and most stains performed well, but adhesion on the untreated composite decking was much more difficult (see Table 2). The ambient temperature crosslinking acrylic had very

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Freshtreated ACQ and CBA lumber is often a preservative-free board and will turn to a light tan color after exposure to sunlight. Both types of wood treatment can be painted or stained as long as the boards have a chance to weather and become seasoned. If they are painted or stained before the wood is seasoned, the preservative may stain or paint stains. Some laboratories have been made to find these stains which might block or prevent this discoloration but no effective stain blocking method was found. The best way found to avoid this discoloration is to allow the treated wood to weather for one month before painting or staining.

COMPOSITE DECKING

There are many types of wood plastic composite (WPC) decking now available. The composite boards are about two times as expensive as treated wood. ACQ-treated yellow pine is $6.57 for a 12-ft board while most composite decking starts at $19.00-$20.00 for a 12-ft board. For a finished deck surface, many of the less expensive wood plastic composites are similar in price to cedar decking or exotic hardwood such as IPE.

There are usually several products with further finishing options available from each composite decking manufacturer. Most of the boards are made with recycled plastic and wood flour or other fibers. Although most composite manufacturers market their products as being relatively maintenance free, there are several reasons why people may want to paint them. A homeowner who wants to change the color of the deck to the color of the trim of his house may paint new composite decking. Many composite boards also will have a significant color fade to gray upon exposure to UV light and may need to be repainted to restore the original color. Finally, weather patterns or staining of the weathered composite decking may make painting them desirable. The maintenance of a composite decking can be easily cleaned by hosing or even washing with a garden hose. These stains are not easily removed and sanding them off is not usually recommended since it can remove the embossed wood grain. Different composite manufacturers have different recommendations for coating their products. Most recommend weathering the panels for two to three seasons before painting but a few manufacturers specifically recommend that their products not be coated at all.

Composite substrates are a more stable substrate than wood decking, and do not have the same tendency to crack. They offer a few challenges for the coatings manufacturer. The trend towards an embossed wood grain on the composite board may mean that a coating will need to be harder and more abrasion resistant in order to avoid both wear on the raised areas of the embossing and excessive dirt picking up in the low areas. Adhesion to the various plastics used in the composite boards can also be a significant problem, depending on the ratios of wood fiber and polymer used, as well as the use of a different extrusion board manufacturing route. The recycled feedstocks used in the boards can vary depending on the availability of the source materials, so there is a potential for significant variation in the quality of the coatings. Another potential problem with many types of composite decks is tannin staining. The wood fibers used in some types can come from oak or other high tannin species, so there can be a significant discoloration of solid color stains. Finally, weathered composite boards may include chalk which can reduce adhesion of deck coatings.

Although there are few deck coatings on the market designed specifically for composite decking, a deck coating can be sold more widely if it can be used for both composite and wood decks. To be used for both substrates, the solid color stain needs to have excellent crack resistance on weathered wood decks as well as good abrasion resistance and good dirt pick-up resistance on both new and weathered composite decking.

TESTING PROCEDURES

Wet adhesion tests are designed to measure paint's ability to retain its grip in wet conditions, to determine the water resistance of a paint. The tests are commonly employed to evaluate wet adhesion, Bohm and Haas chemists also rely heavily on the so-called "force to peel," or "weighted pull," test for this purpose. Chemists find this method particularly appealing because it provides a quantitative measure of wet adhesion that is less subjective than crosshatch and knife peel tests. As in the case of other wet adhesion procedures, it is typically conducted on a variety of substrates including glass, aluminum, glass, and metal, and painted wood.

In the force to peel wet adhesion test, the investigator applies 2.5 g of a test paint to a 1/2 in. x 6 in. section of the substrate with a 1 in. brush. As soon as this process is completed, the investigator centers a 1/2 in. x 9 in. strip of cheesecloth directly over the coated section of the substrate so that 1/2 in. of the strip extends beyond the upper and lower edges of the coated panel. While embedding the cheesecloth in the first coat of paint, the investigator covers the cheesecloth with 7.5 additional drops of paint. The painted panel is then cured at a controlled temperature and humidity after which two parallel lines are inscribed through the cheesecloth and onto the substrate (1/4 in. from each side border along the entire length of the strip). The two cuts create a 1 in. strip in the cheesecloth. This is then placed in a fog box for 30 min or more depending on the severity of the test. When conditioning is complete, the box is removed from the fog box and at- tended to with a moistened side horizontal and tilted forward from the perpendicular. A weight hanger is then attached to the top edge of the cheesecloth with a paper clip or "S" hook. Next, the investigator begins adding weight to the hanger until the cheesecloth begins to peel at a rate of 1 to 20 mm per minute. The weight (grams) at which this degree of peeling occurs is recorded and the score for the paint.

Early water resistance is also an important property for solid color stains. Stains which have poor early water resistance may have color tracked from the deck into the house when the deck is subjected to foot traffic after an overnight dry when there is dew on the deck. Early wet color rub off was tested on drawdowns that were dried overnight and then rubbed with a wet paper towel for 30 strokes. Paints were rated on the amount of color transferred to the towel.

Tannin staining was also evaluated by applying two coats with a four-hour dry time between coats, and then placing the wet panel in high humidity for 16 h. In this severe test, the tannins are drawn into the wettopcoat and differences between solid color stains can be easily seen.

Resistance to household stains was tested by applying 10 ml of each stain to the paint, allowing it to sit for one hou, then removing excess and cleaning the stained areas with 200 cycles using a 1 "Tide" solution. The "Dye F" was then taken between the stained, cleaned area and the unainted area using a two-year footbridge exposure of these solid color stains on composite decking substrates were used for the final analysis of abrasion resistance.

TEST RESULTS

An experimental 100 VOC solid color stain neutral bond application was prepared. This stain had a VOC of 26.3% and a volume solids of 28%. It was thickened with Acrysol RM-2002NPR and Natrosol 250 HHR and contained 20 lb of zinc oxide. These neutral bases were tinted with 15 vg/dt of universal colorants to a solid color. Several binders were evaluated including a conventional exterior acrylic and a new ambient temperature crosslinking acrylic which has excellent grain crack resistance and good adhesion to a variety of substrates. Six commercial solid color stain controls ranging from 100 to 250 VOC were also tested. The commercial controls were also neutral bases and were tinted with the same levels of universal colorants as the experimental paints.

On untreated treated wood, all solid color stains had good adhesion. On three-month weathered treated wood, however, there was a significant difference in the adhesion (see Table 1). The ambient temperature crosslinking acrylic had very good adhesion and was equal to the best of the commercial controls. The effect of the binder chemistry can be seen by comparing the conventional acrylic to the ambient temperature crosslinking acrylic in the same formulation. The stain based on the conventional acrylic had lower wet adhesion to the weathered treated wood than the stain based on the ambient temperature crosslinking acrylic polyacrylate.

On composite decking, the adhesion was different than on treated wood. The weathered composite deck was the easiest to adhere to and most stains performed well, but adhesion on the untreated composite decking was much more difficult (see Table 2). The ambient temperature crosslinking acrylic had very good adhesion and performed better than the VOC compliant acrylic.
Table 3—Stain Blocking and Stain Resistance of Solid Color Series

<table>
<thead>
<tr>
<th>Solid Color State</th>
<th>Paint Base</th>
<th>Acrylic-ambient Crossing Linkage</th>
<th>Conventional Acrylic Polymer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tannin (Reddish) 1-10 10 Best</td>
<td>3-4</td>
<td>6</td>
<td>3</td>
</tr>
<tr>
<td>Tannin (Deaf) 1-10 10 Best</td>
<td>3-4</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Stain Retention (red) 50</td>
<td>14-21</td>
<td>1.0</td>
<td>14</td>
</tr>
<tr>
<td>Stain Retention (gape juice) 50</td>
<td>5.7-8.0</td>
<td>1.2</td>
<td>7.9</td>
</tr>
</tbody>
</table>

Even in a neutral base formulation with 11 oz of universal colorant, the stain based on the ambient temperature crossing linkages had excellent stain resistance. In this case, it was used to help tie up tannins in the first coat and keep it from migrating into the topcoat. The ambient temperature crossing linkages had excellent stain blocking in two coats while the commercial solid color stains and the stain based on the acrylic polymer were poor for this property (see Figure 1).

In neutral bases, the tannin suppression is less than in the pastel bases because of the surfactants in the colorants, but testing has shown that even in the neutral bases most of the tannins are blocked in a stain based on the ambient temperature crossing linkages. The severely bleeding boards which do bleed into the neutral bases. A third coat of the solid color stain based on the ambient temperature crossing linkages was effective at blocking the tannins.

Resistance to common hydrophobic food stains is also an important property for decks. The tight film formed by the ambient temperature crossing linkages gave a deck stain which was very resistant to food stains and was significantly better than the commercial controls. The contribution of the polymer chemistry can again be seen in the difference in the stain resistance between the conventional acrylic and the ambient temperature crossing linkages in the same formulation.

Even in a neutral base formulation with 1 oz of universal colorant, the stain based on the ambient temperature crossing linkages had very good early water resistance as tested by the wet color rub off method (see Table 4). Lab testing of the Taber abrasion resistance was also promising with the ambient temperature crossing linkages having very low levels of weight loss compared to the controls or the conventional acrylic polymer.

Although lab testing of the adhesion and abrasion resistance is an indicator of performance, the best test of the solid color stain is to actually have them exposed to foot traffic on exterior exposure. These stains have now been exposed on footbridges for 2.5 years at the Robin and Haas Exposure Testing Fence. They were applied to several different types of weathered composite decking as well as weathered treated wood. Some of the commercial controls are beginning to fail by cracking and flaking on the weathered wood but the solid stain color based on the ambient temperature acrylic polymer is showing very good durability with no cracking or flaking on weathered wood and very good dirt pick-up resistance. We are not finding any significant abrasion or film removal on high areas of the embossed composite substrates for any of the stains but this may be because composite decking in this footbridge exposure was weathered for three months before coating. This might have been predicted from the lab results since most solid color stains had good adhesion to weathered composite decking.

# CONCLUSION

New substrates for decks present coating formulations with new challenges. In addition to the traditional performance requirements for solid color decking stains, coatings designed for the new substrates must have excellent adhesion to unweathered composite decking and treated woods. The coatings are also expected to perform as well as interior floor paints with good stain resistance, grease resistance, and be easy to clean up. They should be flexible enough to have good crack resistance on weathered wood decking but also be hard enough that they resist dirt and abrasion on composite decking.

Solid color stains based on ambient temperature crossing linkages can be formulated to offer a very good balance of properties which are superior to most commercial latex solid color stains. Stains based on the ambient temperature crossing linkages can be formulated to work well on both weathered treated wood and composite decking.

These ambient temperature crossing linkages can be formulated into neutral bases with excellent water resistance and abrasion resistance, and which offer much better tannin and household stain resistance than conventional acrylic polymers. The ambient temperature crossing linkages also have better adhesion to unweathered composite decking than conventional acrylic polymers and excellent crack resistance on weathered wood. Long-term exposure tests of these ambient cure-crosslinking polymers have shown that they also have excellent exo-xylene durability under foot traffic.

# ACKNOWLEDGEMENT

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# REFERENCES


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The ambient temperature crosslinking acrylic was effective at blocking the tannin.

Resistance to common hydrophobic food stains is also an important property for decks. The tight film formed by the ambient temperature crosslinking polymer gave a deck stain which was very resistant to food stains and was significantly better than the commercial controls. The contribution of the polymer chemistry can again be seen in the difference in the stain resistance between the conventional acrylic and the ambient temperature crosslinking acrylic in the same formulation.

Even in a neat base formulation with 11 oz of universal colorant, the stain based on the ambient temperature crosslinking acrylic had very good early water resistance as tested by the wet color rub off method (see Table 4). Lab testing of the Taber abrasion resistance was also promising with the ambient temperature crosslinking acrylic having very low levels of weight loss compared to the controls or the conventional acrylic polymer.

Although lab testing of the adhesion and abrasion resistance is an indicator of performance, the best test of the solid color stains is to actually have them exposed to foot traffic on exterior exposure. These stains have now been exposed on footbridges for 2.5 years at the Rhode Island University Testing Fence. They were applied to several different types of weathered composite decking as well as weathered treated wood. Some of the commercial controls are beginning to fail by cracking and flaking on the weathered wood but the solid color stain based on the ambient temperature acrylic polymer is showing very good durability with no cracking or flaking on weathered wood and very good dirt pick-up resistance. We are not finding any significant abrasion or film removal on high areas of the embossed composite substrates for any of the stains but this may be because composite decking in this footbridge exposure was pressure treated for three months before coating. This might have been predicted from the lab results since most solid color stains had good adhesion to weathered composite decking.

**Table 3—Stain Blocking and Stain Resistance of Solid Color Stains**

<table>
<thead>
<tr>
<th>Solid Color Base</th>
<th>Paint Base</th>
<th>Acrylic-ambient</th>
<th>Conventional</th>
<th>Acrylic Polymer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tannin (Redwood)</td>
<td>10, 10 Best</td>
<td>3-4</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Tannin (Eucalypt)</td>
<td>10, 10 Best</td>
<td>3-4</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Stain Removal</td>
<td>100 ml</td>
<td>16-21</td>
<td>15</td>
<td>14</td>
</tr>
<tr>
<td>Stain Removal (gum juice)</td>
<td></td>
<td>5-7.8</td>
<td>1.2</td>
<td>1.0</td>
</tr>
</tbody>
</table>

**Figure 3—Tannin suppression on composite decking.**

**Conclusion**

New substrates for decks present coating formulation with new challenges. In addition to the traditional performance requirements for solid color decking stains, coatings designed for the new substrates must have excellent adhesion to untreated composite and treated woods. The coatings are also expected to perform as well as interior floor paints with good stain resistance, grease resistance, and be easy to clean up. They should be flexible enough to have good crack resistance on weathered wooded decking but also be hard enough that they resist dirt and abrasion on composite decking.

Solid color stain based on new ambient temperature crosslinking technology can be formulated to offer a very good balance of properties which are superior to most commercial latex solid color stains. Stains based on the ambient temperature crosslinking polymer can be formulated to work well on both weathered natural wood and composite decking.

These ambient temperature crosslinking stains can be formulated into neutral bases with excellent water resistance and abrasion resistance, and which offer much better tannin and household stain resistance than conventional acrylic polymers. The ambient temperature crosslinking polymers also have better adhesion to untreated composite decking than conventional acrylic polymers and excellent crack resistance on weathered wood. Long-term exposure tests of these ambient cure crosslinking polymers have shown that they also have excellent exsiccation durability under foot traffic.

**Acknowledgement**

The author would like to express his appreciation to Ms. Shelly Fox and Ms. Martha Wixted, not only for the sample preparation and applications testing, but also for their significant contributions to the project design and the interpretation of the results.

**References**


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