

UNDERSTANDING EXTRACTIVE BLEEDING

by
Joint Coatings/Forest Products Committee

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INTRODUCTION

Wood siding can be finished with a variety of products to achieve just about any look desired. Naturally occurring chemicals in the wood itself can migrate to the surface of the siding and discolor the finish. The chance of getting discoloration and the type of discoloration that may occur depends on many factors, including wood species, moisture content, type of coating and coating formulation and construction practices. This paper examines these factors.

DESCRIPTION OF THE PROBLEM

Dry wood is composed of cellulose, lignin, hemicelluloses and minor amounts of extraneous materials. The extraneous materials are both inorganic and organic. The inorganic materials consist of trace minerals accounting for only 0.1 to 1.0 percent of the dry weight of the wood substance.

The organic components of the extraneous materials are referred to as extractives because they can be removed by extraction with solvents without altering the cellulose/lignin structure of the wood. Extractives include tannins and other polyphenolics, coloring matter, essential oils, fats, resins, waxes, gums and starch. Depending upon such factors as species, growing conditions and season of harvest, the total extractive content of wood substance may range from less than 1 percent, up to 30 percent in extreme cases.

Extractives contribute to such properties of wood as color, odor, taste, decay and insect resistance, density, hygroscopicity and flammability.

Extractives are often classified according to the type of solvent which can be used to extract them from the wood. Solvents include water, alcohol, benzene and ether. Once in solution, extractives typically exhibit a reddish brown color. Upon evaporation of the solvent, the colored extractives are deposited on the evaporating surface thereby causing discoloration. When the surface is a painted or stained wood surface, the discoloration can be a problem.

From the standpoint of paint or stain discoloration, by far the most important type of extractives are those that are water soluble. Discoloration of paints or stains may occur when extractives are dissolved into solution by water, reach the painted surface and remain as a grey to reddish-brown stain after the solvent evaporates. This is termed extractive bleeding.

Non-water soluble extractives such as pitch and resin may also interfere with the appearance of a painted surface. In some species, small droplets of pitch may be brought to the painted surface by high temperatures, whereas other species are prone to pitch pockets -

large deposits of hardened pitch. When exposed to high temperatures, these deposits will liquify and run over a painted surface. Additionally, knots of many softwood species contain an abundance of resin which can sometimes cause paint to turn yellow-brown over the knots. This phenomenon is referred to as knot bleeding. Upon further exposure to weather, the discolored paint can become brittle, crack and peel.

CAUSES OF DISCOLORATION

When extractive discoloration occurs, water is typically the primary causal agent. In some species, extractives migrate to the wood surface during the drying process. If concentrations at the surface are high enough, the extractives may interfere with proper penetration, absorption and/or drying properties of the applied finish. Most extractive-related paint discoloration problems, however, occur due to the presence of moisture incurred after installation and painting. These sources of moisture are often easily determined and, in fact, the nature of the discoloration itself may provide clues to these moisture sources.

Diffused discoloration of paint typically results from the penetration of the paint film by liquid water or water vapor. These exterior sources of water include rain, dew, irrigation and high humidity.

Diffused discoloration will usually occur in the first cycles of wetting after painting and can be attributed to a porous or thin paint coat which

is either insufficient or inadequate to prevent water penetration.

The water present as the carrier in water-borne finishes can also contribute to diffused extractive discoloration. Usually, discoloration is evident at the time of application before the finish dries. It is for this reason that either solvent-borne oil or alkyd or stain-blocking latex primers are usually specified for wood species that are prone to extractive bleeding.

A rundown or streaked type of extractive discoloration often occurs with lap siding when water gains access to the unfinished backside of the siding. Here, the water source can be from either the interior or the exterior. Interior conditions causing extractive discoloration include high

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moisture vapor levels, typical of new construction, and/or poor ventilation in high humidity areas. Exterior sources can be leaks in the exterior of the building that allow water to penetrate behind the siding or rain water driven behind lapped siding from winds or capillary action. Rundown extractive type stains can also occur where siding butts into window or door frames if caulking and end priming have been omitted.

Wood left to weather naturally with no protective finish may take on a myriad of color variations, depending upon exposure to sunlight and moisture. Condensation from high humidity can cause darkening of the wood due to the migration of water soluble extractives to the wood surface. When sufficient liquid water and UV are present, the wood may take on a bleached appearance due to the degradation of lignin and leaching of water soluble extractives near the surface.

The initial moisture content of the wood at the time of installation can also contribute to extractive discoloration of coatings. Extractive staining may develop from moisture in unseasoned or "green" siding, or in dried siding which has been exposed to rain at distribution yards or at job sites. Excess water that remains in the wood evaporates as the siding comes into equilibrium with its

surroundings. When initial moisture content is the source of water, the stains will occur during or soon after installation of the siding.

Knot bleeding can occur when a knot contains an excessive amount of extractives. In these cases, the extractives consist mainly of rosin, fats and turpentine, and these extraneous materials can make up as much as 50% of the knot by weight. These oily products can be solubilized by non-aqueous solvents or binders used in solvent-borne oil or alkyd paints and can be absorbed into the paint causing discoloration.

PRODUCTS USED AND THEIR PERFORMANCE EXPECTATIONS

GENERAL

Of the two types of discoloration discussed, staining from water soluble extractives is the most common, especially in species with high extractive concentrations. Water soluble extractives are found in the heartwood of most species, but high concentrations are often found in the heartwood of decay resistant species such as western red cedar and redwood (the decay resistance of these species is attributed to their high extractive content). They also occur in smaller amounts in the heartwood of species with little or no decay resistance and to a much lesser degree in sapwood. On the other hand, non-water soluble extractives, such as pitches and resins, tend to occur most often in species such as ponderosa pine and white pine.

Listed below are some common wood species that may contain high levels of water soluble extractives and species that may contain relatively high levels of pitch and resin. Species in each of these groups can achieve good performance as siding materials and trim when conditioned, installed and finished properly; however, these woods may exhibit discoloration problems when handled improperly or finished incorrectly.

| Extractive Rich Woods | Woods with Pitch & Resin |
|------------------------------|-------------------------------------|
| Redwood | Ponderosa |
| Western Red Cedar | Pine |
| Incense Cedar | Southern Pine |
| Douglas Fir | Douglas Fir |
| Cypress | Spruce |

This is not a complete list, but it does represent species readily available as siding and trim.

There are other factors that will affect the potential of developing natural discolorations. High grade, close-grained wood manufactured from larger, older trees tends to have larger quantities of water soluble extractives and smaller quantities of pitch and resin. On the other hand, sidings and trim manufactured from second or third growth trees tend to have less heartwood and consequently fewer water soluble extractives; but they may also contain more knots and traumatic resin canals which can result in higher levels of pitch and resin.

Extractive staining occurs primarily in two types of wood-based sidings, solid wood siding and veneered siding. Solid wood siding, as defined in this paper, is manufactured from sawn wood. It can be cut directly from the log at the time of log breakdown or it can be remanufactured from dimension lumber. Boards in standard dimensions can be used for solid wood siding, but most solid wood sidings are cut to a pattern, such as bevel, tongue and groove or shiplap. Veneered siding, as the name implies, has wood veneers on the exposed face, while the inner portion, or core, of the siding can be made of veneers or reconstituted wood. Plywood is a common veneered siding that is manufactured in large panels, typically 4' by 8', but veneered siding can also be manufactured in board form and cut to various patterns. Both solid wood siding and veneered siding are available in a variety of surface textures.

SOLID WOOD SIDING

The moisture content of the siding and the method of drying also determine, to a degree, the amount of extractives and pitch that may occur at the surface of the wood. Solid wood siding is manufactured to three basic levels of dryness. Some siding is sold green (wet) with no attempt to eliminate the natural moisture which occurs in the tree and thereby can produce severe extractive staining and finishing problems. Green siding also tends to have more pitch problems. As a result, green siding is not recommended for any building where appearance or overall performance is a major concern unless the siding is allowed to dry to equilibrium with the environment prior to finishing and installation. One way this is done is by placing the siding in stacks, using thin boards, or stickers, to separate each row and allow air movement between the pieces. The equilibration period can take from

several weeks to several months depending on the species and initial moisture content of the siding. For this reason, it is generally easier, more economical and more reliable to use air dried or kiln dried siding.

Other sidings are partially dried to moisture contents ranging from 15 percent to 30 percent moisture content. Partially dried sidings still contain moisture that, in some cases, will cause water soluble extractives to migrate to the surface of new wood. The potential of initially encountering a staining problem with these sidings is dependent on the species and the degree of dryness.

Siding dried to a moisture content between 10-15 percent initially exhibits the lowest potential for producing extractive stains; however, the introduction of moisture into the siding at any time during its service life can cause extractive staining. Although drying to a moisture content between 10-15 percent will help reduce extractive stains, a quality finish system will still be necessary to avoid extractive bleeding caused by moisture during weathering.

Non-water soluble extractives such as pitch and resins can be troublesome in unseasoned siding. The pitches and resins are usually hardened during kiln drying due to the high temperatures encountered in most kiln schedules. This is not normally achievable in green or air dried siding and kiln drying is therefore recommended for resinous woods. This is most critical for the knotty grades of resinous species.

VENEERED SIDINGS

Veneered sidings such as plywood and composite sidings (composed of outer layers of wood veneer and inner layers of veneer and/or reconstituted wood) can be manufactured from a variety of species. Since the individual layers are dried prior to gluing and then hot pressed, they are generally shipped at moisture contents below 10%. Therefore, the potential for encountering a staining problem as a result of the initial moisture content of veneered siding is small. External sources of moisture such as rain, condensation or even waterborne finishes can dissolve water soluble extractives in the outer veneers or around the edges of the siding.

It is not unusual for veneered siding to have considerable variation in extractive content. Face veneers may come from different sections of a tree with different concentrations of extractive content. The concentration

of extractives may vary greatly between species, between trees and within a tree. For instance, the sapwood will normally contain little or no extractives while the extractive content of the heartwood can be very high. Thus, extractive staining may occur on one panel but not on another, or it may even occur only on certain portions of a panel face.

COATINGS

Of the many types of coatings used with wood siding and listed below, only a few have the ability to prevent extractive staining. Unfortunately, these products do not necessarily fit the needs of today's consumer who is often times seeking the "natural" look.

Clear Water Repellents

Clear water repellents or water repellents containing preservatives are typically composed of a solvent, a resin, water repellent such as paraffin and possibly a preservative or mildewcide. Some may contain small amounts of ultraviolet stabilizers. In many cases, the water repellency is short lived, sometimes only several months. Clear water repellents do not offer extended protection against extractive staining. They can be used to minimize staining when siding would otherwise be left exposed (for short periods of time) prior to painting, for example; however, not all paints and stains are compatible over water repellents. Adhesion or penetration problems can result. Care should be taken in following the manufacturer's recommendations on painting or staining a water repellent treated surface. In addition, clear water repellents do not prevent ultraviolet damage. Studies at the Forest Products Laboratory have indicated that paint adhesion can be reduced in as little as 4 weeks as a result of ultraviolet damage to exposed, unfinished wood.⁽¹⁾

Stains

Solvent-borne oil or alkyd stains, whether semitransparent or solid, are similar in composition to clear water repellents with the exception that they contain varying amounts of pigments, resins and total solids. Resins may have an amber cast which is masked by the pigment. The water repelling characteristics of some stains can reduce the amount of water absorbed by the wood, thereby reducing the amount of water soluble extractive discoloration. Because solvent-borne oil or alkyd semitransparent stains do not form a complete film or water barrier, the protection is not reliable. Solid color

stains can form a thin film providing more protection against extractive staining than semitransparent products.

Water-borne latex stains and water-thinned oil stains are more porous, allow more rapid moisture movement into the wood than solvent-borne oil or alkyd stains, and thus do not provide good protection

Clear water repellents do not offer extended protection against extractive staining.

from water soluble extractive staining. Since these stains use water as a carrier for the various components of the stain, they may actually create an extractive discoloration problem at the time of application. This can be particularly noticeable with light-colored latex stains. Although many latex stain labels do not exclude their use over staining species such as redwood or cedar, they may recommend the use of a stain blocking primer, especially for lighter colors. Latex stains are not recommended by the trade associations representing cedar or redwood solid wood siding, but they may be used over veneered products. A stain blocking primer, however, is recommended when light-colored topcoats are used.

Paints and Primers

In all cases for all species of wood, the primer is the most important coat in preventing discoloration when paints are used. Top quality stain-blocking primers prevent the extractives or the resins from being transported to the topcoat.

For extractive-rich solid wood sidings, such as redwood and cedar, an oil base or alkyd resin base primer is the most effective primer for blocking water soluble extractives. These can form a continuous film that is impervious to moisture. Acrylic latex stain blocking primers have been developed; however, two coats are often required for adequate stain blocking on solid wood sidings. For veneered sidings, a stain blocking acrylic latex primer is generally satisfactory.

Some primers are specially formulated to reduce resinous stains in knotty pine and other similar woods. These are typically high solid formulations that provide a barrier to prevent pitch and resin from going through to the topcoat.

For topcoats, two coats of a top quality exterior latex paint, such as an all acrylic latex, should be applied. Not only are these paints easier to use than solvent-borne oil or alkyd paints, but they can withstand dimensional changes of the wood and are less prone to cracking. Solvent-borne oil or alkyd paints are generally less durable and more difficult to use, but for extreme cases of bleeding, they may be the only way to block extractives.

Varnishes

While not recommended for exterior use, alkyd and polyurethane resin based varnishes can be used to prevent water soluble extractive discoloration in interior areas where humidity is high, such as bathrooms, kitchens and swimming pool areas.

Varnishes and shellacs have also been used by painters as primers over knots to prevent knot bleeding. While these products will retard knot bleeding, paint applied over these sealers may often fail prematurely because they do not exhibit sufficient flexibility.

TEST METHODS

Evaluating Stain Resistance of Finishes

Methods for testing the extractive stain resistance of finishes are not standardized; however, several methods have been used by finish manufactures and the USDA Forest Products Laboratory (FPL). Some of these test methods are cited below.

To evaluate initial or flash staining resistance of primers, slow drying under high humidity is one method that has been used. The following is one such method.⁽²⁾ Choose several cedar or redwood

recommended spread rate. On one test area, apply a top coat as the prime coat. Allow the prime coat to dry. Drying times can vary. It has been observed that shorter drying times (4 to 8 hours) will produce more severe staining versus overnight drying.⁽³⁾ The drying time chosen will depend on the amount of primer film formation desired. After drying, recoat the whole board with a top coat applied at the spread rate specified by the manufacturer. The top coat should be one that will dry slowly, preferably one that has a high level of glycol in it.

Immediately after applying the top coat, place the boards in a high humidity chamber in order to retard the dry time and create the best conditions for staining. If no chamber is available, allow the topcoat to dry for approximately 1/2 hour and put a wet layer of cheese cloth over the top coat. (The top coat should be dry enough so as not to redissolve from the water in the cheese cloth.) After the panels have been in the chamber or in contact with the cloth for 16 hours, allow the panels to dry to the touch and evaluate for staining.

Resistance to long term staining can be evaluated using accelerated test methods like the fog box, the blister box or the humidity cabinet. In these tests, the test samples are top coated and allowed to air dry for 24 hours before being tested.

The fog box test subjects the panels to a water spray mist overnight to simulate rain. The blister box test determines the resistance to staining when the wood substrate is saturated with water. It consists of clamping the test panel face up over a container of heated water so that the air at the back of the panel is 140 degrees F. and 95-100% relative humidity. Samples are evaluated after 76 hours. When the humidity cabinet is used, subject samples to 95 degrees F. at 100% relative humidity for 24 hours and then evaluate the samples.

The Forest Products Laboratory in Madison, Wisconsin, used the following long term test to evaluate the stain resisting properties of several water soluble chemicals.⁽⁴⁾ Fifteen-inch redwood and western red cedar samples were divided into five equal sections. Samples were stored at 30% relative humidity and 26.7 degrees C. prior to treatment. The treating chemicals were applied by brush in three different concentrations on the center portions of each sample with the end portions of each sample left untreated. Two coats of a white acrylic latex paint were then applied with a five-hour interval between coats, and then allowed to dry for 24 hours at room temperature. Samples were then placed on open-back racks at 26.7 degrees C. and 90% relative humidity for one to three months. The amount of extractive staining was determined visually by comparing the treated areas to untreated areas and by the use of a tristimulus colorimeter, which measured relative brightness of the tested sections using TAPPI Method T217, M-48, a standard paper test.

Other tests have been developed to simulate high concentrations of extractives in wood. These methods involve extracting water solubles from cedar and/or redwood chips and applying this concentrated solution to wood boards. Test finishes are then applied over the treated boards and evaluated using one of the methods described above.

Evaluating Types of Discolorations

Extractive discoloration of finishes by water soluble extractives can often be confused with stains caused by iron or microorganisms. Simple diagnostic tests are available to differentiate between these causes of discoloration. Mildew will often cause a gray-to-black discoloration in areas of high moisture and restricted air flow. A test to determine the presence of mildew is to apply concentrated liquid chlorine bleach to the surface without scrubbing. If this solution does not remove the discoloration within a minute or so, mildew is not the cause of the stain; whereas, if the discoloration is eliminated, mildew is the likely cause of staining.

Iron stains are also black in appearance and may be associated with nail or fastener corrosion or may be more diffuse in nature. Using a two-part diagnostic solution of 19% hydrochloric acid followed by a 12% aqueous solution of potassium



▲Run-down extractive stain

boards that may be prone to staining, often identifiable by the dark colors and possible dark lines that appear with the grain. Divide a board into six inch (minimum) test areas. Coat each of the test areas with one coat of the primer to be tested applied at its

▼Diffuse extractive siding



ferrocyanide, the presence of iron can be confirmed by a resulting blue color. If this test is negative (and the bleach test is negative), the discoloration present is likely the result of water soluble extractives. In most cases, this diagnosis can be confirmed if the discoloration can be removed by an application of oxalic acid.

Pitch and resin exudation are usually identified by their sticky nature, familiar translucent yellow/orange color and resinous odor. Stains caused by knot bleeding are usually obvious because of their precise association with knots and naturally, can be expected to occur more frequently in more knotty grades of lumber.

FIELD HINTS

Prevention of Extractive Stains

Several steps can be taken to reduce the potential of having extractive staining occur on wood siding and trim. For solid wood siding, an important step is to use properly dried lumber that has a moisture content between 10 percent and 15 percent. All wood-based sidings must be kept dry during shipping and handling. It should be kept under a protective, waterproof cover during shipping and also at the job site and should be stored off the ground in a covered building if at all possible.

Prior to installation, a protective finish should be applied to the face and all edges of veneered panel siding, and to all faces (including the back) and all edges of all other types of siding. This will produce a "balanced" piece of wood that is resistant to moisture developed from both interior and exterior sources and has improved dimensional stability. For some siding patterns, like bevel and shiplap, backpriming is especially important. Wind-blown rain and capillary action can drive water up behind the laps of these sidings resulting in a rundown type of extractive discoloration occurring right under the lap if the siding is not backprimed.

Paint systems provide the best protection against moisture and, therefore, do the best job of preventing extractive stains. For solid wood siding made from wood with high extractive content, either a high quality solvent-borne oil or alkyd stain blocking primer or a top quality latex stain blocking primer should be applied to all sides and edges according to the manufacturer's recommended spread rate prior to

installation of the siding. This should prevent water soluble extractives from coming through the topcoats. For veneered panel sidings, a top quality stain-blocking latex primer, such as acrylic latex, should be applied to the edges and exposed face. Veneered lap sidings should also be backprimed.

Once the proper primer has been used and the siding has been installed, two coats of a top-of-the-line latex paint, such as acrylic latex, should be applied. The topcoat should be applied within 30 days of priming.

Stains do not provide reliable protection against extractive discoloration unless applied to a properly primed surface. When staining solid wood siding and veneered lap siding, as with paints, one coat should be applied to all sides and edges of the siding or trim prior to installation. Latex stains are suitable over veneered products but a stain-blocking primer should be applied when light-colored topcoats are used. For solid wood sidings, solvent-borne oil or alkyd stains are recommended. All stains should contain a mildewcide to help reduce discoloration caused by mildew. In addition, solvent-borne oil or alkyd stains should contain a water repellent.

In interior situations where wood is exposed to high levels of moisture, several thin coats of a polyurethane or alkyd resin varnish will protect the wood from moisture and prevent extractive stains. Kitchens and bathrooms are areas where these finishes would be recommended. Do not use varnishes on exterior wood.

In addition to applying a proper finish, other steps can be taken to reduce moisture-related extractive staining. Here are some suggestions for proper construction:

1. *Adequate overhang* – Use a building design that provides two or more feet of overhang with proper gutters attached. The amount of protection this design detail provides is unequalled, resulting in a much longer finish life and eliminating many situations that cause water stains.

2. *Proper flashing* – Make sure that areas above windows and doors and areas at wall and roof intersections are properly flashed. Do not rely on caulking to seal these building locations. A good job of flashing will prevent water from getting behind the siding, reducing water stain and decay hazard.

Prior to installation, a protective finish should be applied to ... all faces (including the back) and all edges of ... siding.

3. *Caulk correctly* – Adequately caulk areas where water pipes or electrical sources enter the siding. As a rule of thumb, caulk those areas that are susceptible to moisture penetration that cannot be flashed; however, use flashing instead of caulk if at all possible. Avoid the use of pure silicone caulks and "bargain" caulks that can shrink, crack and lose adhesion quickly, allowing moisture penetration. Use high performance, paintable exterior caulks with either an acrylic, silicone acrylic, butyl, polysulfide or polyurethane base.

4. *Ventilation and internal moisture* – Keep the relative humidity in the interior of the building as low as possible. This will reduce the amount of moisture vapor passing through the walls into the siding and will lower the amount of water soluble extractives that accumulate at the surface of the siding. In most climates, and especially in Northern areas, a vapor barrier should be installed under the drywall on the warm side of the wall. Ventilation fans in bathrooms and kitchens as well as dehumidifiers can reduce internal moisture vapor pressure considerably.

CORRECTION OF EXISTING DISCOLORATIONS

Water Soluble Extractives

Water stains caused by concentrations of water soluble extractives often times can be removed. If the stains are removed soon after their appearance, cleaning with warm water and a soft non-metallic bristle brush may do an adequate job. Mild staining from water-soluble extractives is often washed away by rain over a period of several days or weeks. If the stains are old, it may be necessary to wash the area with a detergent solution and a non-metallic bristle brush. One cup of household liquid bleach and one cup of trisodium phosphate dissolved in one gallon of warm water works well. Use a plastic bucket and wear rubber gloves and safety glasses during application. (Caution – never mix bleach with detergent containing



▲ *Extractives from blisters*

ammonia, as the fumes can be harmful or fatal.) After washing the siding, rinse it with clear water and let it dry.

Stubborn stains may require bleaching with a wood bleach. Four ounces of oxalic acid crystals dissolved in one gallon of warm water works well. Use a non-metallic container. Apply this solution with a soft brush and scrub with a non-metallic bristle brush, if necessary. After the area dries, rinse it with clear water and let it dry thoroughly. Alternatively, most paint stores carry commercially available exterior wood cleaners that are pre-mixed and ready to use. Many of these contain oxalic acid and can be quite effective at stain removal. (Caution: Oxalic acid is poisonous, so precautions should be taken. Wear safety glasses and rubber gloves and prevent the solution from coming into contact with skin or eyes. Prevent splashing oxalic acid on plants.)

Occasionally, extractive stains become chemically fixed to the finish itself and do not migrate to the surface, making it virtually impossible to remove all of the discoloration. In this case, paint over the discolored area with a compatible stain blocking primer and topcoat.

Pitch and Resins

Pitch and resin tend to come out of resinous woods during warm weather usually at isolated areas near knots or pitch pockets in the wood.

The pitch and resin can be easily removed with a clean rag and mineral spirits. After cleaning, spot prime the locations with a primer specifically formulated for blocking pitch and resin and refinish as necessary. Dispose of rags properly in order to prevent the creation of a fire hazard.

STATE-OF-THE-ART EXTRACTIVE BLOCKING FINISHES

Non-film-Forming Finishes

Currently, non-film-forming finishes do not provide reliable protection against extractive discoloration. Micronized paraffin wax dispersed in a solvent can provide good water repellency and retard liquid water absorption and extractive dissolution. Wax breaks down relatively quickly, however, and once the water beading has stopped, extractives could appear at the surface.

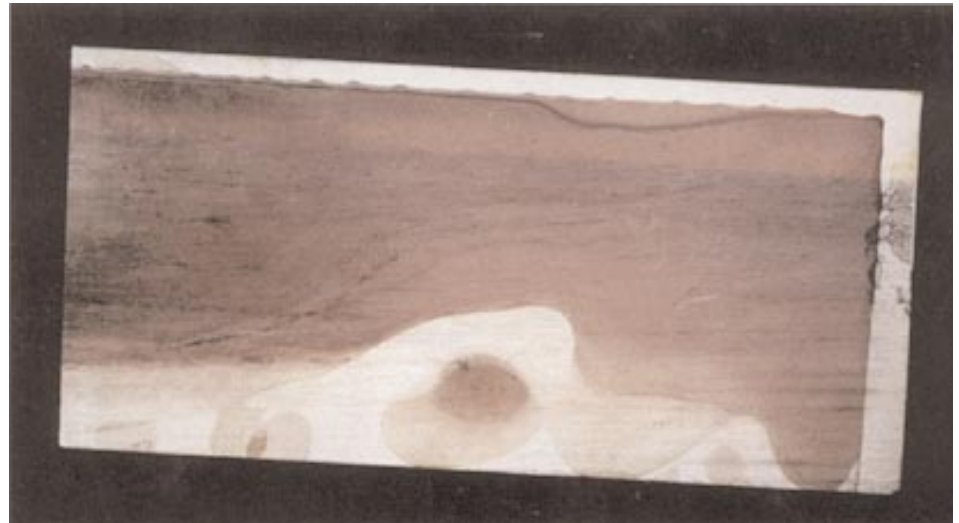
Other systems use 3 or 5 percent silicone water repellents based on silicone resins. These systems do form a film but it is not visible due to their low solids and good penetration. They usually repel water longer than wax dispersions but are normally

used for masonry and are difficult to paint.

Film-forming Finishes

Solvent-borne oil and alkyd resin based film-forming finishes are acknowledged as being the most effective at resisting extractive staining on wood sidings with a high content of water-soluble extractives. They form a film that is less permeable and resists moisture penetration much more effectively than water based finishes, essentially sealing extractives into the wood; however, if these products are thinned excessively or coverage is inadequate, extractive staining can occur.

Water-based stain-blocking primers have been developed that are effective on species with lower extractive content and on veneered sidings. These finishes offer advantages of being environmentally acceptable due to their low VOC



▲ *Extractive discoloration*

Extractive bleeding resulting from ice dams ▼



(volatile organic compound) content, low odor, low toxicity and water clean up. Some stain-blocking latex primers are formulated as a barrier coating to block water-soluble extractives. Other systems function by chemically tying up extractives in the prime coat, preventing further extractive migration into topcoats. With these systems, prime coats typically become discolored, but this discoloration is not transferred to the

CAUTION: Never mix bleach with detergent containing ammonia, as the fumes can be harmful or fatal.

topcoats. Often, manufacturers of these products recommend that two coats of primer be applied if staining occurs, or the use of a solvent-borne oil or alkyd primer. (One system uses an acrylic emulsion polymer additive at approximately 54% by volume⁽⁵⁾.) Many other formulations have been developed and tested. One recent study investigated the effects of dispersants, thickeners, pigments, resins and additives on the stain blocking performance of a latex primer formulation.⁽³⁾ The results of the study indicated that stain blocking effectiveness improved when 325 water-ground mica, activated calcium barium phosphosilicate and a high molecular weight, low functionally, hydrophobic ammonium salt dispersant (NH₄⁺ salt of acid copolymer) were used in the formulation. A non-film-forming cationic acrylic polymer was also identified as significantly improving stain blocking performance. The study also suggested that of the four best performing commercially available products tested, three were low in pigment volume concentration (PVC) and the remaining one used the cationic non-film-forming polymer.

Polyurethane and alkyd resin varnishes are the best finishes to use in interior rooms where humidity is high and extractive staining is possible, such as in kitchens and bathrooms. For knot bleeding, several proprietary knot sealers are available. Varnishes and white pigmented shellacs are also used as spot primers/sealers over knots.

RESEARCH NEEDS

1) The use of solvent-borne oil or alkyd based finishes has been traditionally recommended on those species of wood which are high in

extractive content. Because of environmental restrictions on the solvents used in these finishes, the use of water-borne systems is expected to increase; therefore, a need exists for water-borne finishes which will prevent extractive bleeding to the same extent as that of solvent-borne oil or alkyd finishes. The primary requirements of such finishes are to prevent the penetration of water into the wood and not to have the solvent itself contribute to discoloration.

2) A penetrating primer that could chemically bind the extractives in the substrate through use of special additives would be of interest. The pigmentation should not create other stains in the topcoat because of solubility or reactivity with industrial fumes.

3) Develop a long-lasting water repellent suitable for use with stains. Alternatively, a chemical additive to semitransparent stains that would bind extractives in the wood, as in (2) above, before they discolor the finish would also be desirable.

4) Improve knot and pitch sealers.

CONCLUSIONS/SUMMARY

Extractives are generally classified according to their solubility. Water soluble extractives are most troublesome because of the difficulty of keeping water out of wood that is in service. Extractive stains can appear in several forms. Diffused discoloration can result from rain or dew penetration through the finish whereas rundown discoloration typically results when water collects on an unfinished surface, such as the back of siding or unprimed ends of boards. Water-based finishes can dissolve extractives and cause discoloration as a result.

Several factors will affect the amount and type of extractive discoloration. The heartwood of certain wood species, such as western red cedar and redwood, may have high concentrations of water soluble extractives, whereas other species, like some pines and firs, may have higher concentrations of pitches and resins. The moisture content of the wood substrate also affects extractive staining. Generally, the drier the wood prior to application of the finish, the less chance for initial extractive discoloration. Dried lumber not only has fewer water soluble extractive problems than unseasoned lumber, but kiln drying tends to harden pitches and resins making

them much less likely to bleed; however, introduction of moisture into the siding at any time during the service life can cause extractive staining. The type of finish also plays an important role in preventing extractive bleeding. Non-film-forming finishes like water repellents and semitransparent stains are not effective at preventing extractive discolorations. For water soluble extractives in redwood or cedar solid wood sidings, the most effective finishes are solvent-borne oil or alkyd based film-forming finishes. Water-based stain blocking primers have also been developed that are moderately successful over cedar or redwood solid wood sidings and are preferred over veneered sidings such as plywood. For nonwater soluble extractives, knot sealers and varnishes are currently used.

There are several short term tests available for determining the stain resistance of finishes. These tests involve subjecting the specimen to high humidity using the Fog Box, Blister Box or Humidity Chamber, among others. Long term tests have also been developed, which also use high humidity.

To date, the best method of preventing extractive bleeding is actually a combination of good field practice and the use of quality products. The use of dried siding and quality, moisture resistant finishes or stain-blocking primers are important preventive measures. Good building design and detailing are important as well. If extractive discoloration does occur, it can usually be removed.

Environmental concerns and aesthetic tastes are causing changes that tend to increase the likelihood of extractive bleeding. Lower VOC requirements, the desire for a more "natural" appearance and increased use of lighter colored finishes are examples of some current changes. Additional research to develop improved water based stain blocking finishes that will meet the VOC regulations is needed. It would also be of value to develop a finish system that would chemically bind extractives in the wood, without discoloring the finish itself. This would be particularly useful for light colored stains.

As long as wood continues to be used in exposed conditions, extractive bleeding will continue to be a concern. Education of builders and homeowners as well as continued research in the area of stain blocking finishes is both encouraged and recommended.

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