UNDERSTANDING EXTRACTIVE BLEED

Joint Coatings/Forest Products Committee;
Extractives Task Force

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WOOD EXTRACTIVES: DISTRIBUTION, PROPERTIES, AND CLASSES

Color, odor, and natural durability of heartwood are characteristics imparted by a class of chemicals in wood known collectively as extractives.[1] Wood is converted by the tree from sapwood to heartwood by the deposition of extractives, typically many years after the growth ring undergoing this change was formed by the tree. Extractives are thus not a part of the wood substance, nor do they play a major role in the mechanical strength of wood, but rather are additional materials added as a part of the natural aging process of the tree. Most commercial species that are valued for their appearance owe their merchantability, at least in part, to characteristics imparted by their extractives.

In the wood of most species, extractives are most highly concentrated in knots, which are remnants of branches. When knots appear in boards, they can be problematic for extractive bleed in three main ways. First, knots often have the highest concentration of extractives per unit volume. Second, knots are effectively all end-grain in plain-sawn boards and thus are perfectly positioned to bleed extractives efficiently. Third, knots commonty check and crack during drying or over time in service, thus opening routes through the knot for rapid movement of water (water is used in this article to indicate liquid water), air, or other substances (such as turpentine in pine resins), which often carry extractives with them.

For these (and other) reasons, clear boards (those without knots) have always been preferred for most applications in which wood is finished. As we harvest ever smaller and younger trees, the availability of clear boards will decrease and their price will increase, so it behooves us to learn to mitigate the negative effects of extractive bleed from knots. The changing wood resource also makes the harvest and use of sapwood increasingly more likely, but within that sapwood, knots will each likely bear a small core of heartwood, so the knot–heartwood–extractive dilemma Is likely inescapable.

Extractives can be grouped into two broad categories-water-soluble extractives (WSE) and solvent-soluble extractives (SSE)—depending on the type of liquid in which they dissolve. Grouping extractives in this way is a simple scheme to sort them by broad chemical properties. All WSE share certain fundamental -characteristics, as do all SSE. In theory, all woods have both WSE and SSE, but in practical terms, comparatively few commercial North American species have problematically high concentrations of either type of extractive. Extractive problems for finishes often result from their chemical properties or the structures in which they are found, rather than their concentration In the wood. For example, iron-staining caused by a reaction between steel fasteners and extractives of oak or western redcedar can occur even when extractive concentrations in the wood are at a normal level. Additionally, when extractives are problematic in a species, they are typically extractives of only one class, either WSE or SSE. For example, iron-staining is a phenomenon that takes place when wood becomes wet with water: if it were wetted with mineral spirits or another solvent, one would not expect to see this problem.

Historically, species used and finished for exterior applications have been those with predominantly WSE, such as western redcedar and redwood. In exterior applications, once a piece of wood is installed and finished, for it to be inundated by solvents is almost unheard of, but It will be flushed by water (in the form of rain) regularly, depending on the climate. For these reasons, finish formulations Rave been developed that are effective at blocking these stains from coming to the surface of the finish; that is, we have designed finish systems to combat the most common forms of WSE bleed.

WSE bleed is not purely a problem of extractives in wood but rather is a problem of wood–water relations. As we outline the main ways in which WSE bleed manifests itself and then pre scribe methods for eliminating it, water will clearly be seen as the culprit, and only in association with water can WSE bleed become problematic.

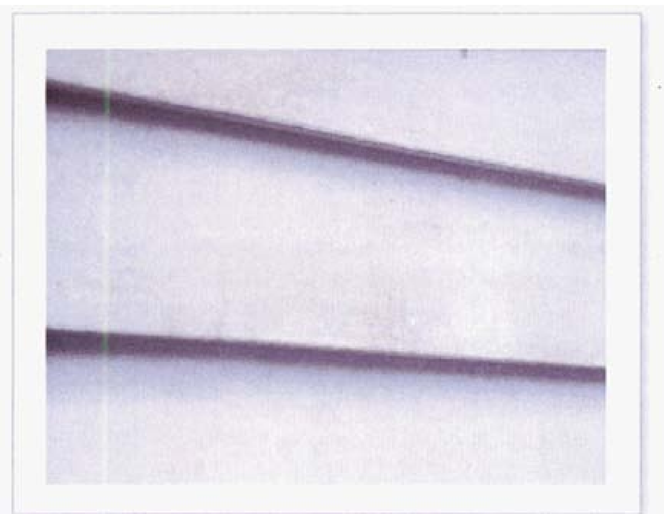

Figure 1 - Diffused extractive bleed.

WATER-SOLUBLE EXTRACTIVE BLEED

When WSE discoloration occurs, water is the primary cause. The secondary cause is long exposure to high humidity, during which time the moisture content (MC) in the board increase beyond acceptable limits. Extractives can migrate to the wood surface during kiln drying, manufacturing storage, installation, or after wood is installed on a structure, as moisture (either water or water vapor) leaves the wood and brings extractives nearer the surface.[2] If concentrations at the surface are high enough, extractives may interfere with penetration, absorption, and drying of some finishes, though this is rare. A more common problem, particularly with waterborne finishes, is the diffusion of WSE into the paint film shortly after application. Most of the WSE diffuse into the paint while the paint film is still wet. Discoloration of the finish by WSE can be eliminated by drying the lumber to less than 19% MC, keeping it dry prior to and during the application of a finish, using the proper finish with a stain-blocking primer, and painting the back side of siding with a water-repellent preservative or primer. Most extractive-related paint discoloration problems occur because water comes in contact with the unpainted back side of siding or the paint used does not adequately block the extractives. Extractive discoloration can show up in a variety of ways, and the discoloration itself may provide clues to the source of water creating the discoloration.

Root causes of WSE bleed are numerous (note that all examples involve water in some form interacting with the wood):

- Diffused discoloration of paint (Figure 1) typically results from penetration of the paint film by water or water vapor. This diffused discoloration usually occurs in the first few cycles of wetting or high humidity after paint application and can be attributed to a porous or thin paint coat that is insufficient to prevent water penetration. The water present as the carrier in waterborne finishes can also cause diffused discoloration. In these cases, discoloration is evident at the time of coating application, even before the coating has dried. Traditional stain-blocking primers were formulated with oil alkyds, which have proven to be best in preventing extractive bleed when applied as the first or primer coat. Recently, coating manufacturers have formulated waterborne stain–blocking primers to comply with regulations restricting solvents in paint. The waterborne systems do not work as well as traditional oil-alkyd–borneformulations, but manufacturers continue to improve them.

- Run-down or streaked type of extractive bleed (Figure 2) indicates that water has gained access to the back side of the siding. This can be caused by washing the wood with high-pressure washers, condensation of water vapor, leaks from improper flashing or building paper use, wind-blown rain behind the siding, or open joints in the wall that permit rainwater intrusion. In the case of siding that has not been end-primed after having been cut to fit around door and window openings, rain can cause this run-down form of extractive bleed. Rainwater easily soaks into the unsealed end grain of the siding where it dissolves extractives in the wood (Figure 3). These forms of stain are best prevented with good building practices.
- Ice dam on roofs can cause water to overwhelm drains and gutters and flow behind rake boards, soffits, fascia, and siding causing extractive bleed (Figure 4).
- Unfinished wood that is allowed to weather naturally may take on various colors from extractives migrating to the surface (Figure 5).
- Initial MC of wood at the time of installation can contribute to extractive discoloration of coatings if the builder fails to acclimate the wood before it is installed. Unfortunately, the time it takes to acclimate wood on the job site in this way is typically prohibitive. Therefore, specifying wood MC from the supplier appropriate to the end-use of the wood is preferable.
- Allowing dried siding and trim, either at distribution yards or job sites, to be exposed to weather can result in extractive bleed after water is absorbed by the wood. Excess water contained in the wood evaporates as the wood reaches equilibrium with its surrounding environment. When initial MC is the cause of extractive bleed, stains will be visible during or immediately following installation.
- Nails and other fasteners damage wood, and water absorbed into these damaged areas may result in localized extractive Meed near the fasteners (Figure 6). This type of extractive bleed is minor and usually disappears within a few week It should not be confused with blue-black iron stain, which is caused by the chemical reaction between iron leaching from low-quality fasteners and tannins in the wood (Figure 7). Tannins are one of many WSE and are found in high concentrations in several commonly used wood species (redwood, many cedars, oak). Minute amounts of iron cause this type of discoloration, and it is extremely difficult to remediate. Although the unsightly blue-black stain can be neutralized with aqueous oxalic acid solution, it will reappear if the source of iron-typically an inappropriate fastener-is not removed. If improper fasteners were

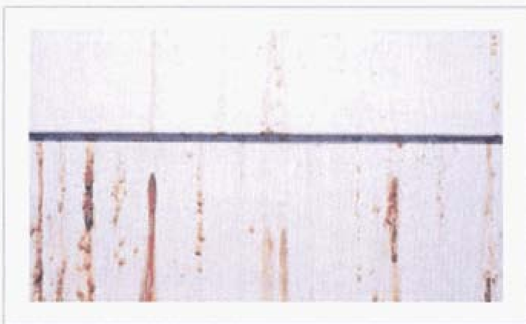

Figure 2 —Rundown extractive bleed.

Figure 3 –Extractive bleed from end-grain adsorption of water. Note the fasteners have also caused iron staining.

Figure 4 - Ice dam on roof and gutter. The resulting water intrusion into the wall and behind the siding often causes rundown extractive bleed.

used to fasten siding to a structure, fixing this is almost impossible (Figure 8). The only long-term solution is to replace the siding– an expensive fix caused by careless selection of fasteners. Use of stainless steel fasteners or consulting with the wood supplier for recommendations regarding fastener choice will help avoid this problem.

To prevent WSE bleed, we recommend that wood be installed and finished at a MC in equilibrium with its end-use environment Finish manufacturers' instructions also recommend this practice to ensure the best performance of their products. Equilibration of the MC helps prevent warping and other problems associated with dimensional change. Installing unseasoned ("green") wood, attempting to coat unseasoned wood, and failure to read and follow installation instructions are often the reasons for WSE bleed.

Several practices can help decrease WSE bleed, including:

- Keep wood products dry during handling and transporting.
- Acclimate wood prior to installation.
- Coat wood only when MC < 19%.
- Use oil-alkyd stain-blocking primer before applying waterborne solid stains and paints.
- Use flashing above all wall penetrations, property sloped to shed water away from the building.
- Use building paper in conjunction with flashing to prevent intrusion of water behind siding or trim boards.
- Incorporate 3/8–3/4in. (9–19-mm) air space between the siding and the sheathing (often referred to as a rain screen).
- Avoid high-pressure water streams, such as power washing, that can force water behind the siding and trim.
- Seal siding and trim end cuts during installation with a water-repellent preservative or oil-alkyd primer. (Sealing the end grain wilt retard the absorption of water for years.)
- Design structures to avoid overwhelming gutter systems, creating ice darns on roofs, or any other feature that allows water to flow behind siding and trim.
- Incorporate features such as porches, hip roofs, and overhangs in the building design to protect walls from water.
- Allow enough space between the ground and first course of siding and trim so that water and snow do not come in contact with siding.
- Position sprinkler systems to avoid wetting the structure.

Figure 5 - Uneven extractive bleed on siding.

Figure 6—Extractive bleed around stainless steel fasteners.

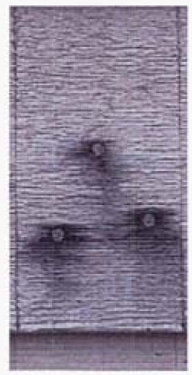

Figure 7 –Iron stain around electro-plate galvanized fasteners.

Figure 8 –Iron stain on newly constructed home. The intent of the owner was to have a natural finish (lightly pigmented semitransparent stain) on the siding. To correct this, the siding will need to be replaced.

If WSE bleed does occur, it will usually be washed away during rainfall and will not cause discoloration. If WSE accumulate in areas that are not washed by rain. it may be necessary to use a cleaner to remove them. A number of commercial cleaners are available in paint stores for cleaning wood and painted wood. Before buying a commercial cleaner, by soap and water. Use a non-metallic bristle brush to lightly scrub the surface and rinse well; if this does not suffice, use a commercial cleaner. Cleaners that contain oxalic acid will likely be effective for removing WSE. Oxalic acid will also remove iron stains and help brighten the wood surface. (Caution: Oxalic acid is poisonous; take safety precautions. Wear eye protection and avoid contact with skin. Cover plants to shield them from cleaners.)

Figure 9 - Pitch bleed from a cut on a tree.

As we have noted, the vast majority of cases involving WSE bleed are caused by water, which can be present in the wood prior to finishing or can enter the wood while it is in service. Wood and finishes are best protected from the ill effects of WSE by employing good design and building practices to avoid contact with water-using dry wood and keeping the wood dry will nearly guarantee freedom from WSE bleed.

SOLVENT-SOLUBLE EXTRACTIVE BLEED

Unlike WSE bleed, in which water is the main and rather predictable culprit, SSE bleed occur via two disparate mechanisms. The first and most readily understood mechanism is analogous to the diffused extractive bleed seen with WSE. Specifically, the carrier solvent in a solvent-borne finish moves into the wood during finishing and while the finish is curing. the solvent volatilizes, pulling extractives to the surface of the wood. This particular form of SSE bleed is rare. The second and much more common mechanism of SSE bleed is known as pitch bleed. Pitch bleed is the bulk flow of large volumes (compared with volumes of WSE) of pitch or resin to the surface of the wood and is particularly common over knots. Pitch and other resins are a defense mechanism that a tree uses to protect itself from harmful pathogens and insects following injury. When a tree's bark is damaged, pitch flows into these areas to protect the wound (Figure 9). Pitch also exists as a normal part of the wood of pines (*Pinus* spp.), spruces (*Picea* spp.), larches (Larix spp.), and Douglas-firs (*Pseudotsuga* spp.), and can be found In specialized wound structures called pitch pockets in the wood of most softwood species. Chemically speaking pitch is a solution of natural rosins and turpentine. Although pitch is an SSE, it exudes from wood by bulk flow without solvent extraction.

Figure 10 - localized pitch bleed.

Figure 11 - Large pitch pocket or seam.

CAUSES OF PITCH BLEED

The ease with which pitch moves through the wood depends on the amount of turpentine that the pitch is dissolved in and the temperature the more turpentine or the higher the temperature, the more fluid the pitch, Another critical component of pitch bleed is an easy path for flow, such as along the grain of a knot or out from a pitch pocket.[2] Pitch Meed can occur in isolated spots (Figure 10) or in large pockets or seams (Figure 11). When pitch bleed occurs, the interaction of turpentine and temperature is the driving force. As wood ages, the turpentine slowly evaporates, pitch becomes less fluid, and pitch exudation decreases and eventually ceases. as temperature of the wood increases, rate of pitch exudation increases, so long as enough turpentine is present in the pitch to allow flow. If the temperature of the wood is high enough, usually from being exposed to direct sunlight, pitch can ooze to the surface. In the Northern Hemisphere, pitch bleed is most commonly found on the southern and western exposures of structures. If the wood surface is finished, pitch may exude through the coating or cause the finish to discolor or blister. Siding and trim manufactured from younger or more rapidly grown trees tend to contain more pitch pockets than that manufactured from older, more slowly grown trees.

PREVENTION OF PITCH BLEED

The only effective way to prevent pitch bleed is to remove the turpentine from the wood during lumber processing. Depending on species, specific kiln drying schedules have been developed to drive off most of the turpentine, thus "fixing" or "setting" the pitch (making it less fluid).[3] Not all end uses of lumber require pitch to be set, so this could be an unnecessary expense and waste of energy. For example, construction grades of lumber, even if kiln-dried, seldom have the pitch set. They are normally dried to 19% MC to achieve dimensional stability. Much of the turpentine has been removed, but if the wood gets warm enough in service, pitch will bleed—not usually a problem for construction grades because the wood surface is seldom visible. The difficulty occurs with appearance grades of lumber, such as for siding and trim. If the pitch is not set during lumber processing, it flows to the surface when the wood warms in service, the turpentine evaporates, and beads of hard rosin are left on the surface of the wood. Completely fixing all the pitch is difficult, and cut end-grain of knots will often exude pitch, regardless of the kiln schedule. Also, the presence of pitch pockets in the wood will effectively preclude the possibility of eliminating pitch bleed.

Solvent-borne finishes, such as oil alkyds, can easily become contaminated with excessive amounts of SSE; waterborne finishes can absorb WSE. Neither type of finish can effectively block the large amount of highly colored extractives that can exude from the end grain of knots. Knots require an effective sealer or an alcohol-borne coating, such as shellac, to seal them, because both WSE and SSE have low solubility in alcohol.[4]

REMOVAL OF PITCH BLEED

If wood exhibits pitch bleed, there are several ways to remove the pitch depending on how fluid it is. If the pitch has not hardened (that is, if it still contains enough turpentine), it can be removed by dissolving it with turpentine or mineral spirits. Once it has hardened, it can be removed fairly easily with a putty knife, paint scraper, or sandpaper. If the pitch is still soft, such procedures smear it over the surface of the wood and paint. If the pitch cannot be easily dissolved with mineral spirits, it is probably best to let it harden and scrape it off. It may be possible to set small amounts of pitch by heating the wood with a heat gun, but this probably will not work for large pitch pockets, such as shown in Figure 11, or those locate deep in the wood.

After removing pitch, the surface should be sanded to bare wood and spot primed with a coat of exterior-grade primer-sealer (not shellac) prior to palming. Shellac can be used to block much of the SSE, and is most effective for indoor applications, but it does not prevent pitch bleed. It should be noted that the paint system does not prevent future pitch bleed during periods of high temperature. The new paint merely fixes the damage. If pitch bleed continues, repainting should be deferred until all exudation has ceased. If pitch bleed is a recurring problem in some boards, it may be necessary to replace these boards. Replaced or repainted boards may show color differences because many paints, particularly oil alkyds, fade as they age.

SUMMARY

Water-soluble extractives (WSE) and solvent-soluble extractives (SSE) can cause premature finish failure on wood. Both classes of extractives have predictable properties based on their chemistry and location within the wood. Prevent WSE bleed by using dry wood; eliminate the intrusion of water with good design and building practices. Both WSE and SSE (other than pitch) tend to bleed from knots, so apply an effective knot sealer prior to priming the wood to prevent extractive bleed, other than pitch bleed. from the knots. Pitch bleed can be prevented by using special kiln schedules to set the pitch. Other than pitch bleed and discoloration over knots, extractive bleed can usually be prevented by control of water and use of proper fasteners. CT

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Authors are members of the Joint Coatings/Forest Products Committee. The committee is co-sponsored by the American Coatings Association and the Forest Products Laboratory and is made up of representatives from the wood and coatings industries. The committee functions through task groups organized to write articles on wood–paintinteraction. **Edward Burke** and **Norm Slavik** are co-chairs of the Extractives Task Group.

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CoatingsTech

Industry News, Science and Technology, and Market Insight

March 2010
Volume 7, Number 3
ISSN:1547-0083