CLEAR EXTERIOR FINISHES:

Finding the Balance Between Aesthetics and Durability

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Consumers can easily be confused by the abundance of choices to make when selecting a clear wood finish. There are many types of clear finishes with different characteristics and product claims. This article is designed to help consumers sort out the different finishes and effectively choose which product would be best for their purpose. First, we cover the causes and mechanism of wood degradation. It is important to know what we are protecting wood from rand why. Then we describe in detail the different kinds of clear wood finishes and how they are designed to work. We also cover the attributes of wood as a building material, which explains why people are so interested in using it in the first place.

INTRODUCTION

Wood has long been admired for its natural beauty, durability, and strength. Because of the increasing value of wood used for exterior applications, such as siding decks, walkways, fences, gazebos, etc., homeowners want to protect their investment by applying a protective finish to the wood. Homeowners and professional painters have traditionally used protective finishes, such as paint, but these finishes hide the natural beauty of the wood. In many cases, the homeowner wants the natural beauty of the wood to show through the finish. This natural wood appearance, although desirable, is difficult to maintain. The harmful effects of nature (primarily sun and rain) degrade the wood surface, both aesthetically and functionally. In recent years, a number of clear wood finishes have been developed that protect wood while accentuating its natural beauty (*Figure* 1). Although the consumer can choose from a vast array of finishes that have a wide range of pigments and hiding

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power, the focus of this paper is on those finishes that have little visible pigment. In some cases, the pigments are included but are finely ground so that the coating is transparent to visible light.

Most natural clear wood finishes are designed to protect and beautify wood. Although this may sound simple, manufacturers' claims that products protect, preserve, seal, last longer, work better, and spread farther than competitors' products are often conflicting and can confuse both the homeowner and professional painter. In fact, many of the terms used to describe exterior wood finishes are used incorrectly, thus adding to the confusion. So let us take a look at the problems facing the homeowner and professional contractor as they try to maintain the natural appearance of wood. In recent articles that compared the performance of various coatings for wood, the performance of clear coatings was often compared with pigmented finishes. To be fair, the pigmented and nonpigmented finishes should not be compared. For example, two years of performance of a penetrating clear finish on a deck would be considered excellent. Two years under the same exposure for a pigmented finish would be considered poor. In comparing clear finishes, it is important to consider the amount and type of pigment that might be included in the finish.

When choosing a finish for wood, there are two elements to consider: aesthetics and protection. These two elements can sometimes be at odds with each other. Aesthetically, there is a growing trend among homeowners to maintain the dear natural look of the wood's original color. However, the best protection from the sun's ultraviolet radiation is obtained from pigmented products, which tend to cover the wood´s natural grain and texture. Thus, the problem arises: how to balance the aesthetic desires of the homeowner for a natural look with the protective requirements of the wood surface

WHY PROTECT WOOD?

Although wood is naturally durable and strong the effects of outdoor exposure on wood can degrade not only these physical properties but its natural beauty as well. Wood exposed outdoors is subjected to both rain (moisture) and sun (ultraviolet radiation), two major factors that can ultimately cause wood to lose both its natural beauty and strength.

Ultraviolet Radiation

Unprotected wood ages when exposed outdoors. The sun's ultraviolet (UV) radiation degrades the surface of unprotected wood within weeks of outdoor exposure (*Figures* 2 and 3). The early phase of UV degradation is manifest as a change in color. Dark wood, such as redwood and the cedars, tends to get lighter after initial installation as the colored extractives degrade. Light wood, such as pine and fir, tends to get darker. As the degradation continues, the lignin at the surface [top 75 to 100 µm (0.003–0.004 in.)] begins to degrade, which in turn loosens the wood fibers at the surface. Rain washes the degraded wood fibers from the surface causing the surface to erode Erosion is more rapid in the less dense earlywood than in the more dense, harder latewood, causing an uneven surface. Mildew growth may also occur as the surface weathers, which darkens the wood's surface. However, in some climates, such as along the seashore, wood tends to weather to a silvery gray. Mildew seems to be less of a problem in these areas. The sun's UV radiation also degrades dear natural finishes.

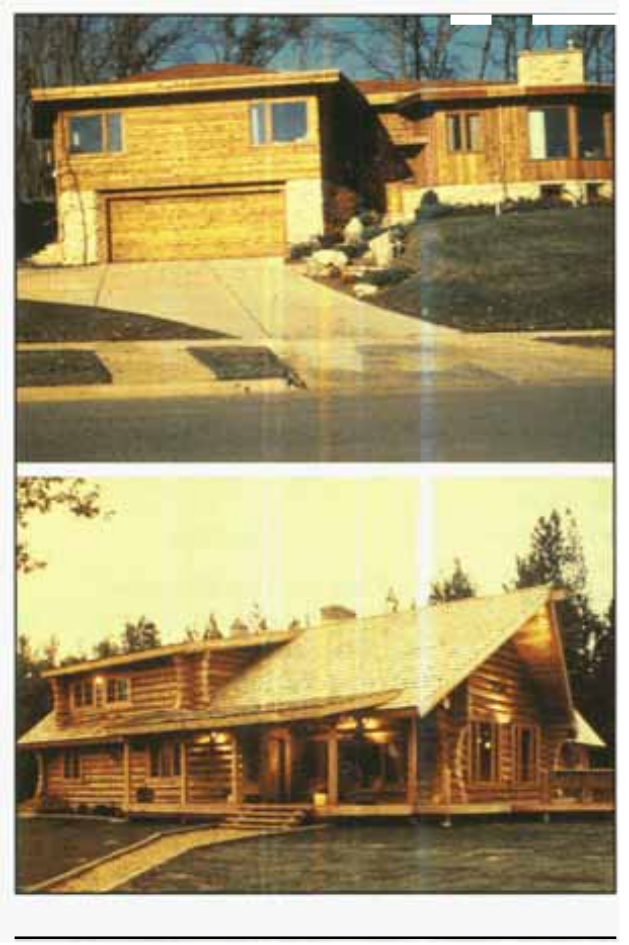
Moisture

Water also degrades wood. Whether in the form of liquid or vapor, absorption and desorption of water causes dimensional changes of the wood, which can lead to premature degradation of the finish. Water causes cracking checking, and warping of the finish and can also lead to decay (rot) in wood. In general, it accelerates the weathering of wood exposed outdoors.

SHRINKING AND SWELLING: Wood shrinks as it loses moisture and swells as it gains moisture. More precisely, wood only changes dimension between an absolutely dry state (completely free of moisture) and its fiber saturation point (the point at which the cell walls of the wood fibers are completely saturated with moisture). This fiber saturation point typically occurs at about 30% moisture for most species of wood. At this point. all the wood's water is bound within the cell wall. As moisture content changes above fiber saturation, the cell cavities take on or lose unbound water but the wood cell walls do not change dimensionally. Below the fiber saturation point, however, the wood will change dimension with changing moisture content.

WATER AND WATER VAPOR EFFECTS: Shrinking and swelling of wood occurs whether the water is in the

Figure 1—Examples of natural finishes on siding and logs.



form of vapor or liquid. For example, wood swells during periods of high humidity and shrinks during periods of low humidity. If wood is exposed to 100% relative humidity (RH) for an extended period, the moisture content will eventually reach the fiber saturation point but it will not go beyond this point without the presence of liquid water. Wood exposed outdoors goes through a daily and seasonal change in moisture content as determined by the RH. It is almost never exposed to extended periods of 100% RH. Even in the hot humid areas of the south, the moisture content of wood stays well below 20% as long as the wood does not get wet. Water, however, can cause wood to quickly reach, and even go beyond, fiber saturation. The source of this water can be rain, dew, melting ice or snow, plumbing leaks, and condensation of water vapor as it moves in or out of a building. The dimensional changes caused by daily and seasonal changes in RH have little effect on the performance of wood finishes.

Poor performance of wood finishes may occur when the moisture content of wood reaches or goes beyond fiber saturation. A large percentage of wood finish degradation (e.g., paint ox stain defects, peeling, cracking) results from moisture changes in the wood and subsequent dimensional instability. Water also decreases paint bond strength, thus increasing the chance for peeling. The wetting–drying cycles of wood exposed outdoors can raise the grain of the wood. If the raised grain is severe, it can cause cracks in paint, particularly in oil-based paints.

For wood finished with clear penetrating finishes, dimensional changes caused by wetting–drying cycles may lead to raised grain, checking, and cracking of the wood. This roughened surface increases water uptake, thus accelerating the degradation process. On flat-grained lumber, the raised grain may appear as thin knife-like feathers along the earlywood–latewood interface.

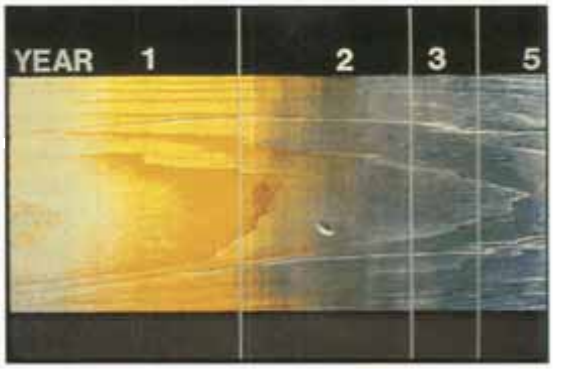
Discolorations

Moisture contributes to many common wood discolorations, such as extractive bleeding, iron stain, and mildew. These discolorations, although not harmful to the wood, give an objectionable appearance to the wood surface.

EXTRACTIVE BLEEDING: Certain types of lumber such as cedar, redwood, mahogany, and Douglas-fir contain water-soluble extractives that can be leached to the surface of the wood (Figure 4). As water moves through wood or as the surface of the wood gets wet, water-soluble extractives are dissolved. As the water evaporates, these extractives are deposited on the exterior surface and appear as a reddish brown stain. If the wood finish is not formulated to block the diffusion of these extractives, they can cause an unsightly residue on the finish, particularly with light-colored finishes. Extractive-related discolorations can be difficult to remove if they are allowed to remain on a surface for a long period of time. Although extractives in wood give the wood its natural color and resistance to decay (for some wood species), they must be sealed in the wood with a stain-blocking primer when using light-colored finishes. Extractive-related discolorations are usually not a serious problem when using dark stain or dear finishes.

IRON STAIN: Iron stain occurs in two ways on wood. Rust from iron or steel fasteners, railings, supports for window air conditioners, etc.,

Figure 2—Surface changes on typical softwood during the natural weathering process.

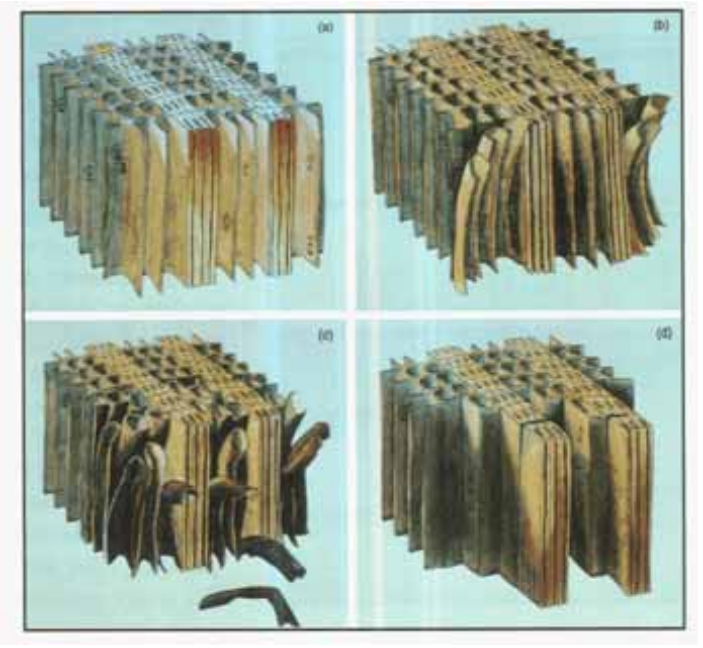


can be washed down a structure by rain and absorbed by the wood or finished wood to cause brown discoloration. Iron can also react with the extractives in wood to give a blue–black stain. Although these stains can sometimes be removed by treatment with oxalic add or sodium biflouride, it is best to mid the problem by using corrosion resistant materials.

MILDEW: Airborne mildew spores are ubiquitous and microscopic and therefore are difficult to detect until they colonize a surface. They are transported easily by air currents, insects, and animals. These spores can cause mildew fungus growth on any surface that provides a food source. Food sources for mildew include wood extractives, plant and tree pollens, natural oils such as linseed and tung oils, bacteria, dirt, and other natural organic materials. Because mildew uses organic materials for food, it has a greater tendency to grow on organic surfaces such as wood, leather, and paper rather than inorganic surfaces such as aluminum, vinyl, and glass. Mildew can also grow on these substrates, but it must then depend on airborne food sources. Although extractives and natural oils give some species of wood their deep rich color, these organic compounds also make wood an ideal substrate for mildew growth, if there is enough moisture available (Figure 5). Therefore, because wood has readily available food for mildew growth, mildew grows more readily on bare wood surfaces than on painted wood, particularly wood painted with synthetic organic polymers such as acrylics.

Following colonization, mildew needs food, moisture, air (oxygen), and moderate temperatures [usually between 4.4°C and 32.2°C (40°F and 90°F)]. Because of the extreme of conditions in which it can flourish and the wide variety of species, mildew is very hard to control and impossible to totally eliminate. Of the requirements needed for mildew growth, moisture is the only one that can be controlled. It is impossible to control colonization, food source, temperature, or oxygen, and it is difficult to control moisture; therefore, paint and stain companies incorporate mildewcides in their products to retard mildew growth.

Figure 3—The weathering process (degradation worsens A through D).



In the absence of a mildewcide, wood that gets wet or damp (even for a short period of time) may develop mildew. As the mildew fungi grow, they become visible because they often develop highly colored pigmentation. Gray or black coloration is the most typical, but various other colors commonly occur. The mildewcides found in paints and stains are not very effective in destroying pre-existing mildew. Therefore, it is important that mildew be completely destroyed prior to staining or painting.

CLEAR NATURAL FINISHES

Stain and paint manufacturers have produced a number of clear products to meet the aesthetic desires of the homeowner while meeting the requirements of wood protection. Clear natural finishes generally fit into four categories: waterproofing, water-repellent sealers, wood preservatives, and UV-resistant clears (blocking or absorbing). Some dear natural finishes on the market today may be combinations of these categories. High solids, water-based, oil emulsion, and traditional solvent-based formulations are just a few examples of the different types of dear finishes sold within each of the categories of dear natural finishes. Air quality regulations have limited the amount of volatile organic compounds (VOCs) permissible in paints, which has motivated paint manufacturers to formulate an abundance of new water-based dear finishes. Another reason for the abundance of new finishes is consumer demand. Some of these new clear natural finishes may be film-forming and therefore, they may not penetrate the wood´s surface very well. Clear finishes also degrade from UV radiation and moisture. For penetrating finishes, this degradation is not serious because the wood can be refinished without extensive surface preparation; film-forming finishes often require extensive surface preparation, even to the extent of complete removal of the old finish, prior to refinishing. Thus, when choosing a clear product, it is important to match the aesthetic desires and the exposure to the weather with the protective requirements of the wood and, at

Figure 4—Examples of extractives bleed on finished wood.

the same time, to understand the performance limitations of the finish.

Waterproofing Products

Waterproofing clear products are often confused with water-repellent products. Waterproofing products form a membrane designed to withstand hydrostatic pressure (like wind-driven rain) and keep water out of a home throughout long periods of wetting. Waterproofing coatings are often elastomeric and are designed for brick, stucco, and other masonry surfaces, not wood. They are products used around flashing to completely stop water absorption.

Water-Repellent Sealers

Water repellents shed water for short periods, like rain or water from a sprinkler. They are not completely impervious to water absorption. Clear products that fall into the water-repellent category are the penetrating finishes. They typically contain a small amount of wax (1–3%), usually paraffin, or other water-repellent material that decreases the amount of water absorbed into the wood, thus decreasing dimensional changes, warping and splitting. They also contain an oil or resin that helps seal the surface and a solvent to facilitate absorption of the other ingredients.

Water repellents were traditionally formulated with organic solvents; however, contemporary formulations may be water-based or solvent-based, or in some cases, may use paraffin oil with no other solvent. The type and amount of material used to impart water repellence may affect future paintability of the treated surface. Water-repellent sealers designed for use prior to painting have about 1% wax or similar water repellent in a curable resin. Because moisture is repelled, mildew growth may be slowed but is not prevented. These products often provide spectacular beading of water upon initial application. However, they offer wood little protection from the sun's UV radiation or mildew growth; they weather to gray and then black from the growth of mildew, unless a mildewcide is added to the product (see the Wood-Preserving Finishes section). When water-repellent sealers are subjected to degradation by the sun's W radiation, the result is a gradual loss of the water beading effect. The life expectancy of these products typically ranges from six months to one year on horizontal surfaces (for example, decks) and one to two years on vertical surfaces, The exposed surfaces of lumber are typically lateral grain. These sealer treatments do not absorb very well into lateral gain; however, they absorb readily into the end-grain of lumber and thus give many years of efficacy preventing end-grain absorption of water. Since the end-grain of wood absorbs water much more readily than the lateral grain, protecting end-grain is more critical to long-term durability than protecting the lateral grain. Treating each piece of wood before it is placed into use ensures end-grain penetration of the sealer.

Wood-Preserving finishes

Clear wood-preserving finishes differ from Water-repellent finishes in that they also contain an appropriate amount of a U.S. Environmental Protection Agency (EPA) approved and registered fungicide. These clear finishes are very similar in appearance to water-repellent sealers. If the fungicide is incorporated to preserve the wood itself, the product must be EPA registered. If the fungicide is present only to protect the clear finish, the product does not have to be registered. The commonly used fungicides are also effective in controlling mildew (mildewcides).

Fungicides are important to all dear natural finish formulations, and most manufacturers incorporate some level of them into their products. The addition of these specific EPA-approved fungicides to the product, in specific quantities, and the subsequent EPA registration, allows manufacturers to make specific claims about controlling decay and mildew when describing their products. Some common fungicides used in these products that can provide decay and mildew resistance to wood include 3-iodo-2-propynyl butyl carbamate, zinc naphthenate, copper naphthenate, bis (tributyltin) oxide (TBTO), N-trichloromethylthio phthalimide, and copper-8-hydroxyquinolate.

Penetrating wood-preserving finishes may also be used as a treatment for bare wood before priming and painting or in areas where old paint has peeled, exposing bare wood. This treatment gives a second "wall" of protection against water that has penetrated the paint film. This is especially effective to prevent absorption of water at joints and at end-grain, thus decreasing the swelling of the wood. As a result, less stress is placed on

the paint film and its service life is extended. For treating bare wood, make certain that the manufacturer's label indicates that the clear wood preservative is paintable. Some products have too much wax or other water repellent and the paint will not adhere adequately or dry properly.

Water-repellent sealers and clear wood-preserving finishes give some protection to the wood surface from weathering by minimizing the effects of water. The wax in the product ultimately breaks down on the exposed lateral surfaces, and the water beading properties decrease. The life expectancy of the water repellency of these products typically ranges from six months to one year on exposed surfaces. However, the water repellent absorbed in the end-grain will be effective for many years. Also, after the wood has gradually weathered, additional treatments may last longer because the weathered boards absorb more finish. The UV radiation can still degrade the surface causing the release of wood fibers and thus the erosion of the surface. Including a UV absorber or some other type of UV stabilizer in the formulation can slow this degradation for a short time.

ULTRAVIOLET-RESISTANT CLEAR FINISHES

The only way to slow the UV degradation of the surface is to incorporate a pigment or a UV stabilizer into the formulation. Thus, the UV-resistant clear water-repellent preservative represents the broadest category of clear natural finishes on the market. Pigments and organic chemical additives are used as light absorbers (ox screeners) to protect the products' binders and the wood from degradation by the sun's UV radiation. The pigments that are used most frequently are either a transparent form of iron oxide (transoxide) or ultrafine titanium dioxide that reflects UV radiation. The organic chemical additives are of two types–UV absorbers (UVA) and hindered amine light stabilizers (HALs).

Ultraviolet absorbers are designed to absorb selective portions of sunlight, especially UV radiation, and dissipate that energy as heat. During this process, some absorbers are destroyed, limiting the effective life of the product. The HALs act as scavengers for the components of the finish (binder and pigments) during degradation and then block further degradation of the dear finish and the wood. Generally, UVAs, HALs, and pigments are used together and offer the best protection to the wood surface.

Many people feel UV-resistant dear finishes are the solution to the delicate balancing act of the aesthetic desires of the homeowner and the protective requirements for the wood. The UV-resistant clears are not as dear as water; they impart a slight color or tone to the finish because they contain translucent transoxide pigments or titanium dioxide. Thus, with UV-resistant clears, various shades of color are available. Transoxide pigments are translucent and thus highlight the natural grain, texture, and beauty of the wood. Transoxide pigments are also versatile; they are used not only in traditional solvent- and oil-based product formulas but also in the latest formulas that meet tighter air quality (VOC) regulations, such as oil emulsion, high solid oils, and water-based formulations. The penetrating and film-forming characteristics can vary considerably among these types of products. The life expectancy of a UV-resistant clear finish is typically twice that of other dear finishes and can range from one to two years on horizontal surfaces (for example, decks) and two to four years on vertical surfaces.

WHY WOOD ANYWAY?

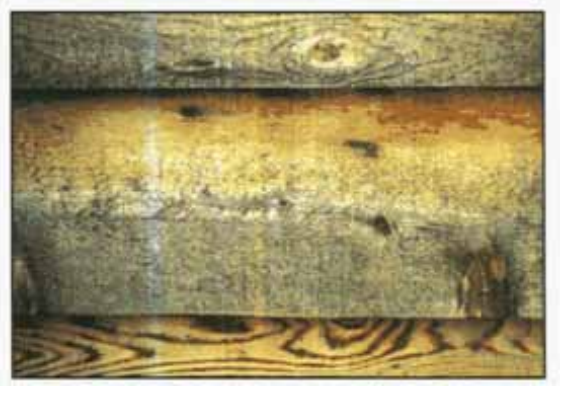
Wood is the material of choice for a wide range of building projects. It offers the builder a long list of features that work together to meet the end user's expectations for service, cost, and appearance.

Perhaps the greatest attribute of wood is its versatility. Wood can be used indoors and outdoors in both structural and appearance applications. Whether the needs are clear or knotty appearance, rough or smooth texture, wood can meet the changes in design and fashion. It can be specified from the hundreds of standard sizes and patterns or custom ordered to meet particular needs. Wood products are widely distributed and readily available throughout the United States and Canada.

Another factor favoring the use of wood is its ease of handling and fabrication. Wood can be shaped, drilled, cut, and fastened with common tools that can be operated by homeowners and professional contractors alike.

Buildings constructed from wood have a history of excellent service. Interior beams, ceilings, paneling. and trim will last the lifetime of the building. Wood products are widely used for exterior siding. trim, decks, and landscape projects. Species such as redwood and cedar contain natural preservatives that make them particularly well suited to exterior environments.

Figure 5—Mildew on wood siding.



Using wood rather than other materials is environmentally friendly. The production of wood products generally requires much less energy than producing alternative products, which lowers both fuel consumption and air emissions. And, wood is the only mewable building material. The nation's move toward sustainable forestry practices (for example, the planting of more than two billion trees each year in North America) assures a continued supply of wood for generations into the future.

The beauty of wood has long been admired. The warm colors and rich grain patterns have decorated homes and their landscapes for centuries. This natural beauty can be enhanced and preserved through the proper selection, application, and maintenance of a finish.

SUMMARY

Matching the aesthetic desires of homeowners with the protective requirements of wood using technologies available today is a delicate balancing act. By having an understanding of the benefits and limitations of the various natural clear finishes, the homeowner's expectations for performance and maintenance can be satisfied. Determining which product to use can be difficult Product quality is often defined by the reputation of the manufacturer, the ingredients used (in sufficient quantities to be effective), and the delicate blending and balancing of the various raw materials used in the coatings formula. High quality, dear wood finishes should be easy to use, contain mildew-preventing ingredients, provide some degree of water repellency, and contain UV radiation absorbers. Generally, clear finishes fully exposed to the weather last one to two years; however, some last less than a year. Research is needed to achieve a quantum leap in the technology of clear finishes for wood. CT

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