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Wood preservation

When wood is exposed to various environmental conditions, many degradation reactions (biological, ultraviolet, mechanical, moisture, and chemical) can occur. To protect wood from biological degradation, chemical preservatives are applied by nonpressure or pressure treatment. Penetration and retention of a chemical depend upon the wood species and the amount of heartwood (more difficult to treat) or sapwood (easier to treat). The objective of adding preservatives is to achieve long-term effectiveness for the wood product, thus sequestering (capturing and storing) carbon.

With the recent voluntary decision by United States and Canadian industries to phase out arsenic-containing pressure-treated wood for residential uses (for example, play structures, decks, picnic tables, landscaping timbers, residential fencing, patios, and walkways/boardwalks), alternative preservatives such as ammoniacal copper quat (ACQ) and copper azole (CBA) are replacing the most widely used chromated copper arsenate (CCA) treatments. By 2004, the U.S. Environmental Protection Agency (EPA) will not allow CCA products for any residential uses. However, it has not concluded that CCA-treated wood that is currently used in or near the home or that remains available in stores poses unreasonable risks to the public. Beyond these replacements for CCA may be wood protection systems based on non-toxic chemical modifications to prevent biological degradation. Chemical modification alters the chemical structure of the wood components, thereby reducing the biodegradability of the wood and increasing its dimensional stability when in contact with moisture.

Preservatives. Wood preservatives can he divided into (1) oil-type, such as creosote and petroleum solutions of pentachlorophenol, and (2) waterborne Salts that are applied as solutions, such as CCA, ACQ, and CBA. The effectiveness of each preservative can vary greatly, depending upon its chemical composition, retention, depth of penetration. and ultimately the exposure conditions of the final product.

Exposure conditions. There are three exposure categories: (1) ground contact (high decay hazard product is usually pressure-treated); (2) aboveground contact (low decay hazard; product is not usually pressure-treated), and (3) marine exposure (high decay hazard; product often needs a dual treatmerit).

Wood preservatives should always be used under ground (soil) contact and marine (salt-water) exposure conditions. Oil-borne preservatives such as creosote and solutions with heavy, less volatile petroleum oils often help protect wood from weathering; however, they may adversely influence its cleanliness, odor, color, paintability, and fire performance. Waterborne preservatives are often used when cleanliness and paintability of the treated wood are required. In seawater exposure, a dual treatment (waterborne coppercontaining salt preservatives followed by creosote) is most effective against all types of marine borers.

Exposure conditions and length of product lifetime need to be considered when choosing a particular preservative treatment, process, and wood species. All these factors are considered by the consensus technical committees in setting reference levels required in the American Wood-Preservers' Association (AWPA), the American Society for Testing and Materials International (ASTM), and the Federal Specification Standards.

Efficacy. The efficacy of a particular preservative and treatment process depends on four basic requirements: toxicity, permanence, retention, and depth of penetration into the wood. Toxicity refers to a preservative's effectiveness against biological organisms, such as decay fungi. insects, and marine borers, that attack wood. The active ingredients in wood preservative formulations are many and varied, each has its own mode of action, and some of these modes are still unknown or unreported. In general, mechanisms of toxicity involve denaturation of proteins, inactivation of enzymes, cell membrane disruption (causing an increase in cell permeability), and inhibition of protein synthesis. Permanence refers to the resistance of the preservative to leaching, volatilization, and breakdown. Retention specifies the amount of preservative that must be impregnated into a specific volume of wood to meet standards and to ensure that the product will be effective against numerous biological agents (see **table**).

Evaluation of the efficacy of preservative-treated wood is performed first on small specimens in the Laboratory and then on larger specimens in the field. The Forest Products Laboratory of the U.S. Department of Agriculture Forest Service has been conducting in-ground stake test studies on southern pine sapwood since 1938 in Saucier, Mississippi, and Madison, Wisconsin. These test sites expose the wood to decay and/or termite attack. A comparison ofpreservative-treated small wood panels exposed to a marine environment in Key West, Florida, has also been conducted. Such outdoor evaluations compare various preservatives and retention levels under each exposure condition at each individual site. The preservatives and treatments tested include creosotes, waterborne preservatives, dual treatments, chemical modification of wood, and various chemically modified polymers.

Retention levels of creosote and some waterborne preservatives for lumber, timbers, and plywood exposed to various conditions*

Preservative	Preservative retention, kg/m^3 (lb/ft^3)		
	Salt water†	Ground contact and fresh water	Above ground
Creosote	400 (25)	160 (10)	128 (8)
CCA (types I, II, or III)	40 (2.50)	6.4 (0.40)	4.0 (0.25)
ACQ (types B or D)	NR	6.4 (0.40)	4.0 (0.25)
CDDC as Cu	NR	3.2 (0.20)	1.6 (0.10)
CC	40 (2.50)	6.4 (0.40)	4.0 (0.25)
CBA (type A)	NR	NR	3.27 (0.20)

* Retention levels are those incluced in Federal Specification TT-W-571 and Commodity Standards of the American Wood-Preservers' Association CCA = chromated copper arsenate, ACQ = ammoniacal copper quat. CDDC = copper bis(dimethyldithiocarbamate), Cu = cooper, CC = ammoniacal copper citrate, CBA = copper azole, and NR = not recommended.

† Dual treatments are recommended when marine borer activity is known to be high.

Timber preparation and conditioning. Preparing timber for treatment involves carefully peeling the round or slabbed products to enable the wood to dry more quickly. Drying the wood before treatment opens up checks (small cracks) before the preservative is applied, thus increasing penetration and reducing the risk of checks opening up after treatment and expos ing unpenetrated wood. Drying also helps to prevent decay, insect damage, and staining, but when treating with waterborne preservatives by certain diffusion methods, high moisture content levels may be permitted.

Treating plants that use pressure processes can condition green material (newly cut trees) by means other than air and kiln drying, thus avoiding a long delay and possible deterioration. When green wood is to he treated under pressure, one of several methods for conditioning may be selected. A steaming-and-vacuum process is used mainly for southern pines, and a boiling-under-vacuum (Boulton) process is used for Douglas-fir and sometimes hardwoods.

Heartwood of some softwood and hardwood species can he difficult to treat. Wood that is resistant to penetration by preservatives, such as Douglas-fir, western hemlock, western larch, and heartwood, may be incised before treatment to permit deeper and more uniform penetration. Incision involves passing the lumber or timbers through rollers that are equipped with teeth that sink into the wood to a predetermined depth, usually 13–19 mm ($^1/_2$–$^3/_4$ in.). The incisions open cell lumens along the grain, which improves penetration but can result in significant strength reduction. As much cutting and hole boring of the wood product as is possible should be done before the preservative treatment; otherwise untreated interiors will allow ready access of decay fungi or insects.

Treatment processes There are two general types of wood preservation methods: pressure processes and nonpressure processes. During pressure processes, wood is impregnated with preservatives in a closed vessel above atmospheric pressure. In commercial practice, wood is put on cars or trams and run into a long steel cylinder, which is then closed and filled with preservative. Pressure forces are then applied until the desired amount of preservative has been absorbed into the wood.

Pressure processes. Three pressure processes are commonly used fullcell, modified full-cell, and empty-cell. The fullcell process is used when the retention of a maximum quantity of preservative is desired. The steps include: sealing the wood in a treating cylinder and applying a vacuum for a half-hour or more to remove air from the cylinder and wood admitting the preservative (at ambient or elevated temperature) to the cylinder without breaking the vacuum; applying pressure until the required retention is attained and withdrawing the preservative from the cylinder. In addition, a short final vacuum may he applied to free the wood from dripping preservative.

The modified full-cell process is basically the same as the full-cell process except for the amount of initial vacuum and the occasional use of an extended final vacuum.

The goal of the empty-cell process is to obtain deep penetration with relatively low net retention of preservative: because a smaller amount of the chemical is used in this process, it is less costly and more environmentally friendly than full-cell processes. Two empty-cell processes (the Rueping and the Lowry) use the expansive force of compressed air to drive out part of the preservative absorbed during the pressure period. The Rueping empty-cell process is often called the empty-cell process with initial air. Air pressure is forced into the treating cylinder, which contains the wood, and then the preservative is forced into the cylinder. The air escapes into an equalizing or Rueping tank. The treating pressure is increased and maintained until the desired retention is attained The preservative is drained, and a final vacuum is applied to remove surplus preservative. The Lowry process is the same as the Rueping except that there is no initial air pressure or vacuum applied. Hence, it is often called the emptycell process without initial air pressure.

Nonpressure processes. The numerous nonpressure processes differ widely in their penetration and retention of a preservative. Nonpressure methods include surface applications of preservative by brushing or brief dipping; cold soaking in preservative oils or steeping in solutions of waterborne preservative; diffusion processes with waterborne preservatives: and vacuum treatment.

Purchasing and handling of treated wood. The EPA regulates pesticides, of which wood preservatives are one type. Preservatives that are not restricted by the EPA are available to the general consumer for nonpressure treatments, whereas the sale of others is restricted to only certified pesticide applicators. These preservatives can he used in only certain applications and are categorized as "restricted use." Restricted use refers to the chemical preservative, not to the treated wood product. The general consumer may buy and use wood products treated with restricted-use pesticides; the EPA does not consider treated wood a toxic substance, nor is it regulated as a pesticide.

Consumer Safety Information Sheets (EPA-approved) are available from retailers of treated wood products. The sheets provide users with information about the preservative and the use and disposal of treated-wood products. There are consumer information sheets for three major groups of wood preservatives: creosote pressure-treated wood, pentachlorophenol pressure-treated wood, and inorganic arsenical pressure-treated wood.

There are two important factors to consider when deciding which preservative-treated wood to choose, depending upon the intended end use of the wood the grade or appearance of the lumber and the quality of the preservative treatment in the lumber. The U.S. Department of Commerce American Lumber Standard Committee (ALSC), an accrediting agency for treatment quality assurance, has an ink stamp or end tag for each grade stamp and quality mark. These marks indicate that the producer of the treated-wood product subscribes to an independent inspection agency. The stamp or end tag contains the type of preservative or active ingredient, the retention level. and the intended exposure conditions. Retention levels are usually provided in pounds of preservatives per cubic foot of wood and are specific to the type of preservative, wood species, and intended exposure conditions. (Note that mention of a chemical in this article does not constitute a recommendation; only chemicals registered by the EPA may be recommended.)

For background information see CREOSOTE; ENVIRONMENTAL TOXICOLOGY; WOOD DEGRADATION WOOD PROPERTIES in the McGraw-Hill Encyclopedia of Science & Technology

Rebecca E. Ibach

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