Technical Note

Effect of salt water evaporation on tracheid separation from wood surfaces

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Abstract

This study simulated the seawater wetting of marine piling, which sometimes results in development of fuzzy, brown surfaces just above high tide level. Untreated and treated (chromated copper arsenate (CCA) and creosote) blocks were intermittently wetted with distilled water or synthetic seawater and dried at 130°F (54°C). Tracheid separation first became apparent after about 100 wet/dry cycles and gradually became more pronounced. Tracheid separation was more pronounced in latewood than in earlywood and in blocks with a greater retention of CCA. Scanning electron and light microscopy revealed checks along the microfibril angle in tracheid walls of CCA-treated wood repeatedly wetted with seawater.

When wood is used in marine environments, road salt and fertilizer warehouses, and chemical plants, it sometimes develops a fuzzy surface suggestive of mechanical abrasion (Fig. 1). This phenomenon is particularly common in the first 1 to 2 feet (0.3 to 0.6 m) above the high water line of marine piling treated with chromated copper arsenate (CCA) and has generated concern among marina operators. Wood that has been damaged in this way has been found on wharves, pilings, and buildings exposed to the ocean, in road salt and fertilizer warehouses, and in a urea production plant. [1]The chemicals are thought to penetrate into the wood as solutes in the water, and crystals of the chemicals form when the water evaporates.

On oceanfront wharves and pilings, this damage was originally noticed on wood that had little or no creosote treatment. It is now being noticed on CCA-treated wood in new construction, most commonly in southern waters and after about 5 years of exposure. This type of damage apparently does not occur with heavily creosoted wood because water and salts do not readily penetrate the wood. It is very noticeable on CCA-treated piling because the light brown color of the fuzzy surfaces contrasts with the light green surrounding areas.

The primary objectives of this research were to 1) demonstrate in the laboratory that salt crystal growth resulting from evaporation of seawater causes tracheid separation and a "fuzzy" surface on southern pine; and 2) determine where the crystals form and how they result in tracheid separation. A secondary objective was to compare this phenomenon on untreated boards and boards treated with CCA or creosote.

Methods and materials

Field and laboratory observations were made on CCA-treated pilings and sections. Experimental work was done on southern pine (*Pinus* sp.) sapwood cubes, 1.5 inches (38 mm) on each side, that were either untreated or treated with CCA to 0.3 and 2.5 pcf (4.8 and 40 kg/m^3 or with creosote to 25 pcf (400 kg/m^3). Three blocks per each treatment were wetted with 1

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[1] Wilcox, W., E. Botsai. and H. Kubler. 1991. Wood as a Building Material: A Guide for Designers and Builders. John Wiley & Sons, N.Y. p. 119.

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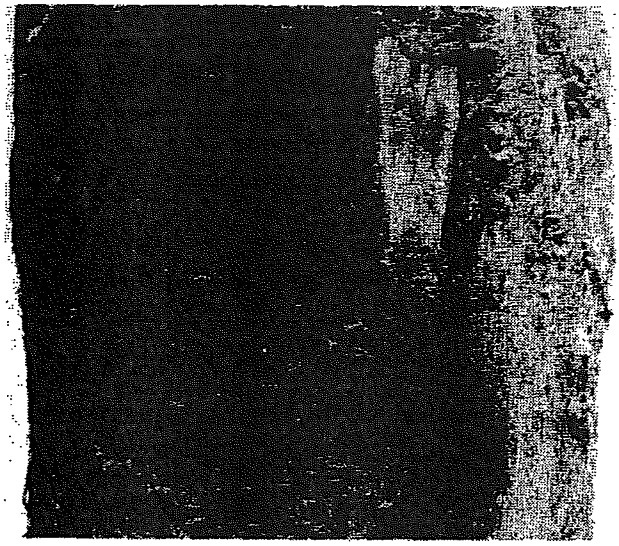

Figure 1. — Section from above high tide level of CCA-treated marine piling (approximately 10 in. or 250 mm in diameter) after about 5 years of exposure in Tampa Bay, Florida. Growth of salt crystals within wood cell walls has resulted in tracheid separation and a fuzzy surface.

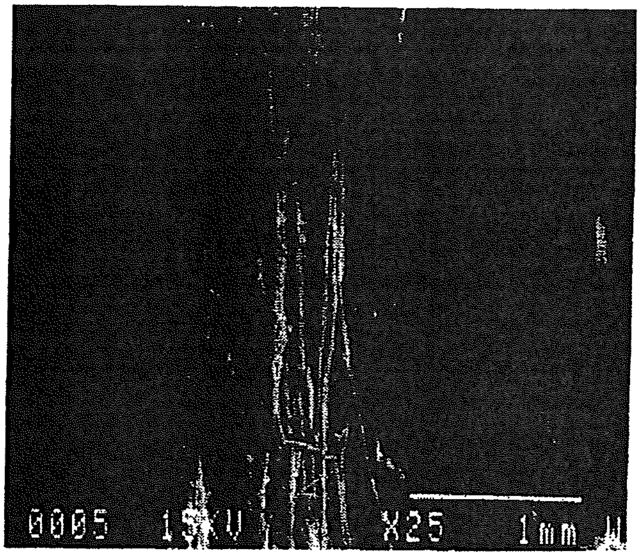

Figure 2. — Scanning electron micrograph of surface of a southern pine block treated with 2.5 pcf (40 kg/m³) CCA and then alternately wetted with seawater and dried 388 times. Note that tracheid separation mainly occurred within the thicker-walled latewood tissue. Magnification x 25.

TABLE 1. — *Effect of 388 cycles of simulated seawater wetting and drying on tracheid integrity.*

Preservative treatment	Water treatment	Tracheid separation	Tracheid microchecking
None	Distilled	None	Very slight
	Seawater	Moderate	Slight
CCA			
0.3 pcf (4.8 kg/m³)	Distilled	None	Slight
	Seawater	Moderate	Slight
2.5 pcf (40 kg/m³)	Distilled	None	Slight
	Seawater	Severe	Severe
Creosote			
25 pcf (400 kg/m³)	Distilled	None	None
	Seawater	Moderate	None

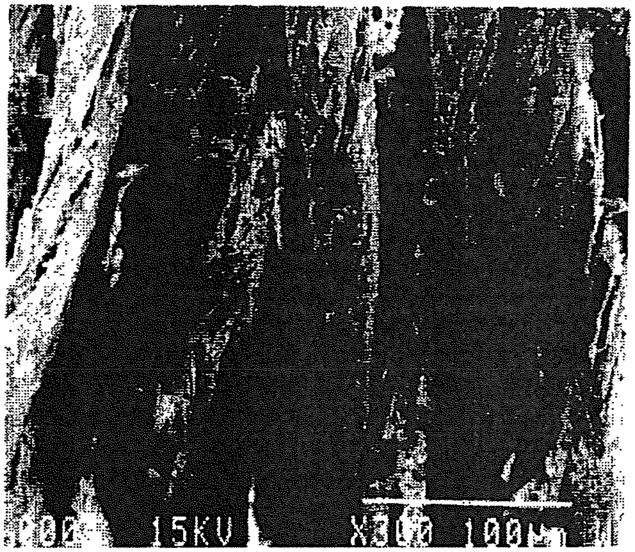

Figure 3. — Same specimen as that in Figure 2, at higher magnification, and after washing with distilled water to remove salt encrustations. Note checks following microfibril angle in tracheid walls. Magnification x 300.

ml of distilled water or aquarium-quality synthetic seawater. The water was pipetted onto the center of one edge-grain face of each block at about 0800; after 2 hours, the block was ovenheated at 130°F (54°C) for 3 hours, followed by reapplication of 1 ml of water (to the same area), a 2-hour period in the oven with no heat, and heating at 130°F (54°C) until 0800 the next morning. This procedure was continued through 388 wet/dry cycles.

Surfaces were rated visually for the amount of tracheid separation (fuzziness) – severe, moderate, light, or none– and examined with scanning electron and light microscopy. The results are listed in Table 1.

Results and conclusions

Laboratory simulation of seawater wetting and solar drying produced tracheid separation after about 100 wet/dry cycles. Separation was most pronounced in blocks previously treated to 2.5 pcf (40 kg/m³) CCA (Table 1, Fig. 2), but it also occurred in blocks treated to 0.3 pcf (4.8 kg/m³) CCA or with creosote and in untreated blocks. Separation did not develop in treated or untreated blocks that were wetted with distilled water. This confirms that tracheid separation is not a result of migration of the CCA preservative itself.

Test blocks treated to 2.5 pcf (40 kg/m³) CCA and wetted with seawater, and marine pilIng in service exhibited extensive fine checking along the microfibril angle of tracheid walls (Table 1, Fig. 3). Little or no microchecking was evident in blocks wetted with distilled water or in blocks treated with creosote or low retention of CCA and wetted with seawater. The severe checking is attributed to embrittlement of the wood by the high CCA retention coupled with the growth of (seawater) salt crystals within the tracheid walls. We also attribute the tracheid separation in our test blocks and in-service marine piling to growth of salt crystals within cell walls, resulting in microchecking and then separation in the region of the lignin-rich middle lamella. This accounts for the brown color of the fuzzy surfaces that develop within a few feet of the high tide level on CCA-treated marine piling, after several years of intermittent seawater wetting and exposure to the sun.

Wood surface degradation that is similar in nature but usually more severe than degradation in marine piling has been observed inroad-salt storage buildings constructed of CCA-treated lumber and poles. The storage sheds are typically constructed of poles or timbers with planking nailed on the inside. The most severe wood destruction typically occurs on the bottom plank and on the bottom 1 to 2 feet (0.3 to 0.6 m) of the pole or timber after 5 to 10 years. Some fuzzy surfaces also develop on the outside of upper planking, but below the level of the salt pile within the building. Storage buildings of the same design constructed of creosote-treated wood have experienced little destruction in 30 years.

The discoloration and fuzzy surfaces of CCA-treated marine piling may be alarming in appearance and aesthetically displeasing, but they likely have little effect on pile serviceability. Wood below the pile surface is insulated from rapid solar drying and therefore less prone to develop salt crystals in tracheid walls and consequent separation and checking. Occasionally, the problem extends in streaks up the full length of piling and causes some degradation of the pile tops as well. Apparently, these streaked areas of the piles have more effective capillary flow paths so that the seawater rises higher on the piles before it is evaporated by solar heating, leaving salt crystals behind. Creosoted piling in service does not degrade in this manner, presumably because creosote in the tracheid lumens blocks the capillary flow of seawater. The tracheid separation in our creosoted test blocks is attributed to the mode of wetting. We applied the salt water directly to the wood surface. Thus, the water could directly penetrate cell walls without first being drawn by capillarity through cell lumens.

Remedial action for marine piling could entail methods that interfere with either capillary flow up the pile or subsequent drying of the pile surfaces. A plastic wrap or coating should accomplish this. Pile caps might be used where degradation of pile tops is pronounced.

For road-salt storage buildings constructed of CCA-treated wood, brine formed from moisture absorption by the salt should be prevented from reaching or evaporating from outside surfaces of the wood. Plastic could be installed on the inside of the planking if it were protected from physical damage by the salt and equipment. On the outside, the lower planks and bottoms of poles could be covered with grease or asphalt to prevent drying and consequent salt crystal growth.