Effect of Silicon/Paraffin Treatment on Dimensional Stability of Red Oak, Douglas-Fir, and Ponderosa Pine

Connie S. Love
Jeffrey J. Morrell

Abstract

Red oak, Douglas-fir, and ponderosa pine lumber was treated with a silicon/paraffinic system to assess the ability of the treatment to limit dimensional changes and moisture uptake during changes in temperature or relative humidity. The treatment initially had little effect on either property, but the magnitude of weight gain and dimensional changes tended to decline with repeated moisture cycles. The results suggest that the silicon/paraffin treatment had the potential to limit vapor moisture sorption and could reduce the potential for wood to deform with repeated moisture cycles.

Wood is inherently sensitive to changes in moisture and responds by weight gain along with differential changes in dimension as wood moisture content increases from 0 percent to the fiber saturation point (typically 25% to 30%, wt/wt; US Department of Agriculture [USDA] 2010). These changes are not generally a problem if they are accounted for in the design, but they can pose challenges in applications where the dimensional changes induce subsequent physical deformation and splitting. Wood users have long labored to control physical deformation through various procedures, including impregnation with monomers that are subsequently polymerized in situ, bulking with glycols, and treatment with various compounds that react with the hydroxyls in cellulose to limit moisture absorption. None of these procedures are completely effective in all applications, and there is a continuing search for alternative treatments that are easily applied but effective.

Pentacryl is a proprietary product containing siliconized polymers with paraffinic oils that has been used by wood crafters to stabilize wood materials; however, there are no data on the ability of this mixture to maintain wood stability under changing relative humidities. In this study, the ability of the silicon/paraffin system to stabilize wood was explored on three wood species.

Materials and Methods

Douglas-fir (*Pseudotsuga menziesii*), ponderosa pine (*Pinus ponderosa*), and northern red oak (*Quercus rubra*) lumber was cut into clear samples measuring 25 by 75 by 127 mm long. A total of 54 specimens were produced for each species.

The blocks were oven-dried (50°C) and weighed. One-half of the blocks of each species group were soaked in water for 14 days at 5°C and then placed in plastic bags and stored for an additional 2 weeks to allow the absorbed moisture to become more evenly distributed. The specimens were then weighed. Average moisture contents after soaking were 28.8, 44.4, and 48.1 percent for the Douglas-fir, ponderosa pine, and red oak, respectively.

The wetted and ovendried blocks were then allocated to be either left untreated, soaked for 7 days in silicon/paraffin solution (hereafter referred to as silicon; Pentacryl, Preservation Solutions LLC, Golden, Colorado), or pressure treated. The pressure process consisted of immersing samples in an excess of silicon in a treating cylinder, drawing a vacuum (8 kPa) over the solution for 30 minutes, raising the pressure to 1.08 MPa, and holding this pressure for 3 hours. Each treatment group (moisture condition/treatment process) contained eight specimens per species. The treated specimens were wiped clean of excess treatment solution before being weighed to determine net solution uptake and then remeasured as described above.

The samples were conditioned to a constant weight at 65 percent relative humidity and 23°C. Sample dimensions on all samples were then measured, and these measurement

The authors are, respectively, Senior Faculty Research Assistant and Professor, Dept. of Wood Sci. and Engineering, Oregon State Univ., Corvallis (connie.love@oregonstate.edu, jeff.morrell@oregonstate.edu [corresponding author]). This paper was received for publication in May 2013. Article no. 13-00047.

Forest Prod. J. 64(3/4):144–147.
doi:10.13073/FPJ-D-13-00047

locations were marked. These values served as the baseline for detecting subsequent changes in mass and dimension. The samples were then moved to a room maintained at 32°C and 90 percent relative humidity until they reached a stable weight. All of the samples were weighed and their dimensions remeasured. This process was repeated for two more cycles to determine if silicon treatment affected specimen moisture behavior. The differences in mass and dimension between these values and those for the original condition (65% relative humidity/23°C) served as the measure of any effect of pentacryl on moisture behavior. The time intervals between moisture conditions varied from 28 to 45 days, depending on how long it took the block weights to stabilize at a given condition. The results for each treatment were summarized and plotted to determine if silicon had any effect on moisture behavior with cyclic moisture exposure.

Results and Discussion

All samples treated with silicon experienced weight gains following treatment, the greatest effects occurring with those that were pressure treated (Table 1). Samples that were first soaked in water prior to treatment and then soaked in the silicon/paraffin mixture tended to have the lowest uptakes for a given species. Uptakes in samples that were soaked in water and then pressure treated tended to be similar to those that were soaked in silicon/paraffin in the ovendried condition. The highest uptakes were found with ovendried samples that were pressure soaked. The presoaking was included because one of the recommendations for use of this mixture is to apply while the wood is green. This clearly had a negative effect on silicon/paraffin uptake.

Red oak samples generally experienced the largest uptakes for a given moisture condition/treatment process followed by ponderosa pine. Both of these species are very receptive to treatment. Douglas-fir heartwood samples absorbed the lowest amounts of solution, reflecting the refractory nature of heartwood of this species (USDA 2010).

As expected, all samples experienced weight gains and increases in dimension when moved from the low- to the high-humidity environment regardless of wood species, condition at time of treatment, or type of treatment (Figs. 1 through 3). These results indicate that silicon was unable to completely alter the wood/moisture relationships of the species tested. While silicon can interact to some degree with wood polymers, no effort was made to use heat or other processes to encourage this process (Mai and Militz 2004a). Thus, the inability of the treatment to completely inhibit moisture sorption is not surprising.

Both red oak and ponderosa pine tended to experience similar increases in swelling regardless of the treatment, while Douglas-fir heartwood experienced slightly less swelling. Similar trends were noted for weight gains. The reported swelling values for red oak and Douglas-fir are

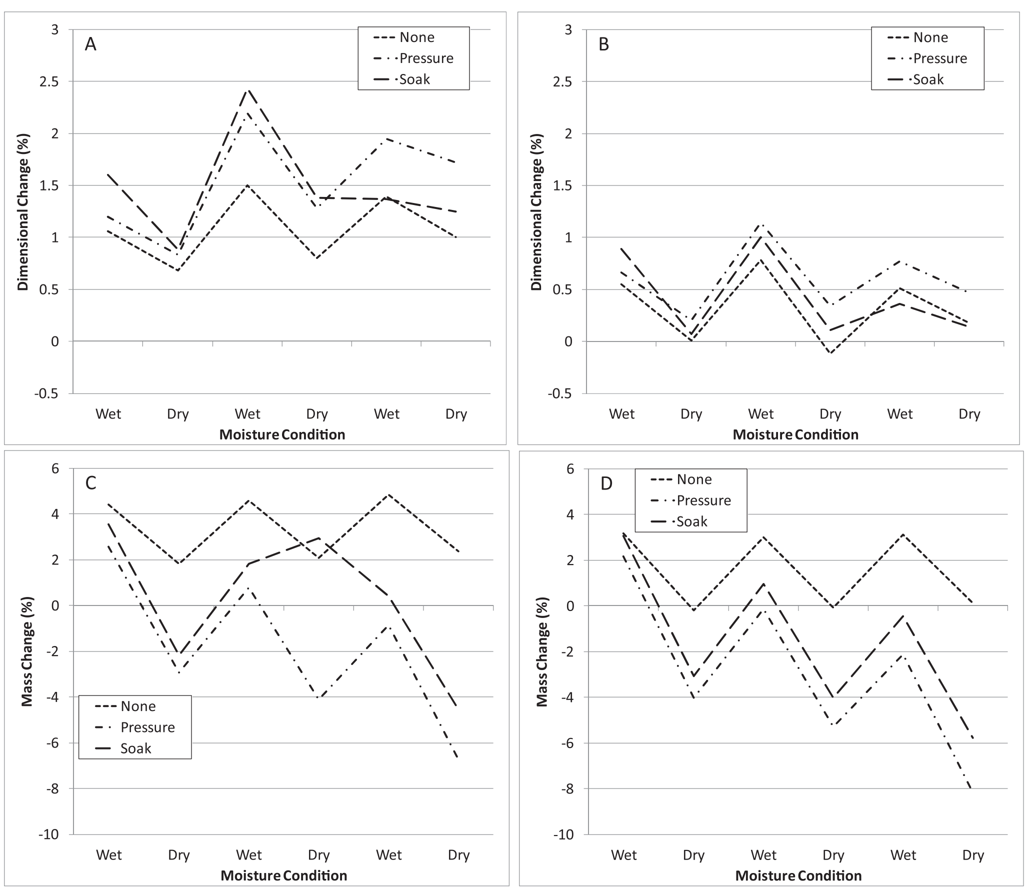

Figure 1.—Effect of soaking or pressure treatment of red oak lumber that was either treated in the ovendried state (A and C) or treated after soaking (B and D) with a silica/paraffinic-based solution on changes in dimension (A and B) or mass (C and D) during cyclic moisture changes. Values represent means of eight samples per treatment. Wet signifies exposure at 32°C/90 percent relative humidity (RH), while dry signifies exposure at 23°C/65 percent RH.

Table 1.—Uptakes of a silica/paraffin-based wood stabilizer applied to ovendried or wet samples using soaking or pressure treatment.[a]

Wood species	Pretreatment moisture condition	Net uptake (%wt)	
		Soaking	Pressure treatment
Red oak	Ovendried	38.7 (7.3)	61.6 (13.0)
	Soaked	14.3 (3.7)	40.0 (7.8)
Douglas-fir	Ovendried	22.2 (2.5)	50.4 (40.0)
	Soaked	6.5 (5.5)	24.8 (17.8)
Ponderosa pine	Ovendried	33.1 (4.6)	51.4 (45.7)
	Soaked	11.5 (3.2)	32.7 (36.4)

[a] Values represent means (one standard deviation) of eight samples per species per treatment.

13.7 and 12.4 percent, respectively, while ponderosa pine should be somewhat less susceptible to swelling (USDA 2010). The somewhat lower swelling rate of Douglas-fir may reflect the presence of only heartwood in our test samples.

There appeared to be no initial trend with swelling or weight gain versus treatment with the first moisture cycle, although the nontreated samples were often slightly more susceptible to moisture uptake. However, repeated moisture cycling produced steady declines in both dimensional change and weight gain of both Douglas-fir and ponderosa pine treated with silicon. Samples with no treatment tended to experience similar dimensional and weight changes with each moisture cycle. There were, however, two exceptions to these trends. There were no noticeable differences in weight gain for treated and nontreated Douglas-fir samples treated while wet or green, although dimensional changes in the same samples were reduced with silicon treatment. Red oak control samples tended to experience lower dimensional changes than those treated with silicon regardless of whether they had been treated while wet or dry. Weight gains on these same samples tended to be greater on controls. The reasons for these anomalies are unclear, but the trend was for reduced weight gain and dimensional change with silicon treatment in two of the three species tested. The silicon effect was also more pronounced in samples that were pressure treated, suggesting that increased silicon retentions had a greater effect on moisture behavior.

The seemingly delayed effect of the silicon/paraffin mixture on moisture behavior is perplexing. Water-based silicones typically produce marked improvements in resistance to water uptake as evidenced by changes in antiswelling efficiency, but these effects are obvious at the first wetting cycle (Schneider and Brebner 1985, Lukowsky et al. 1997, Mai and Militz 2004b, Donath et al. 2006). These tests typically involved impregnation of water into wood, producing much higher weight gains than observed in

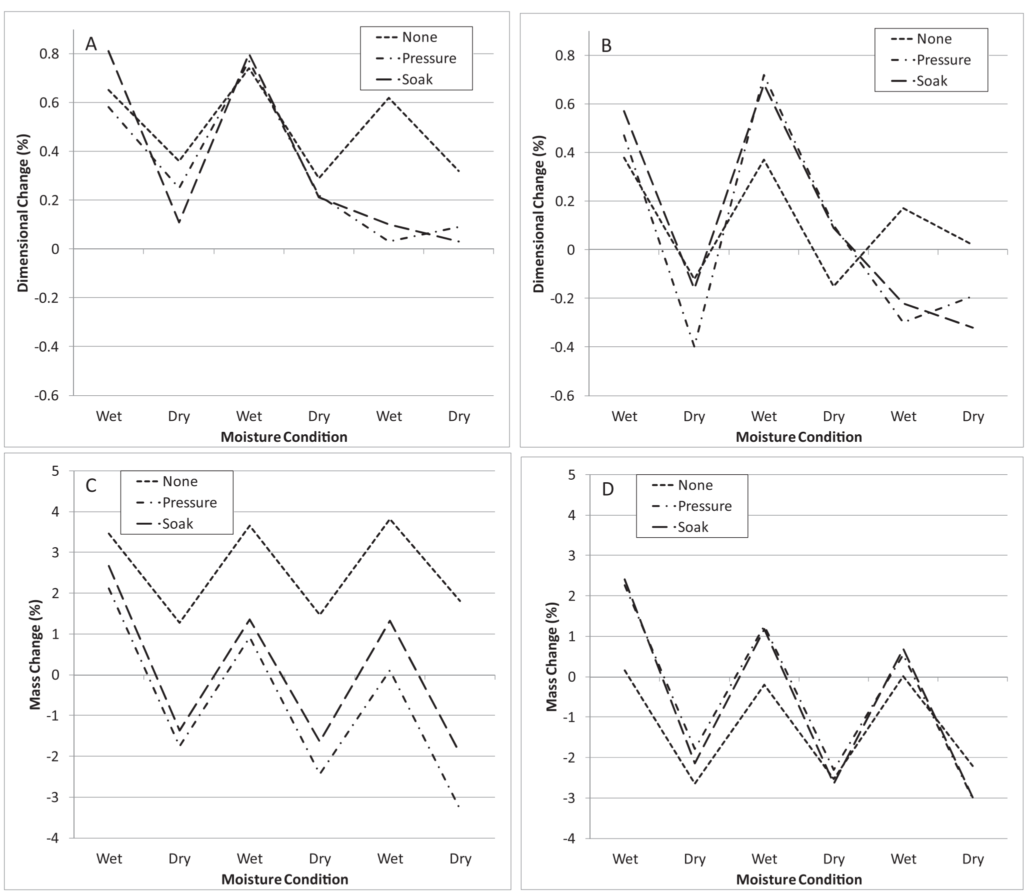

Figure 2.—Effect of soaking or pressure treatment of Douglas-fir lumber that was either treated in the ovendried state (A and C) or treated after soaking (B and D) with a silica/paraffinic-based solution on changes in dimension (A and B) or mass (C and D) during cyclic moisture changes. Values represent means of eight samples per treatment. Wet signifies exposure at 32°C/90 percent relative humidity (RH), while dry signifies exposure at 23°C/65 percent RH.

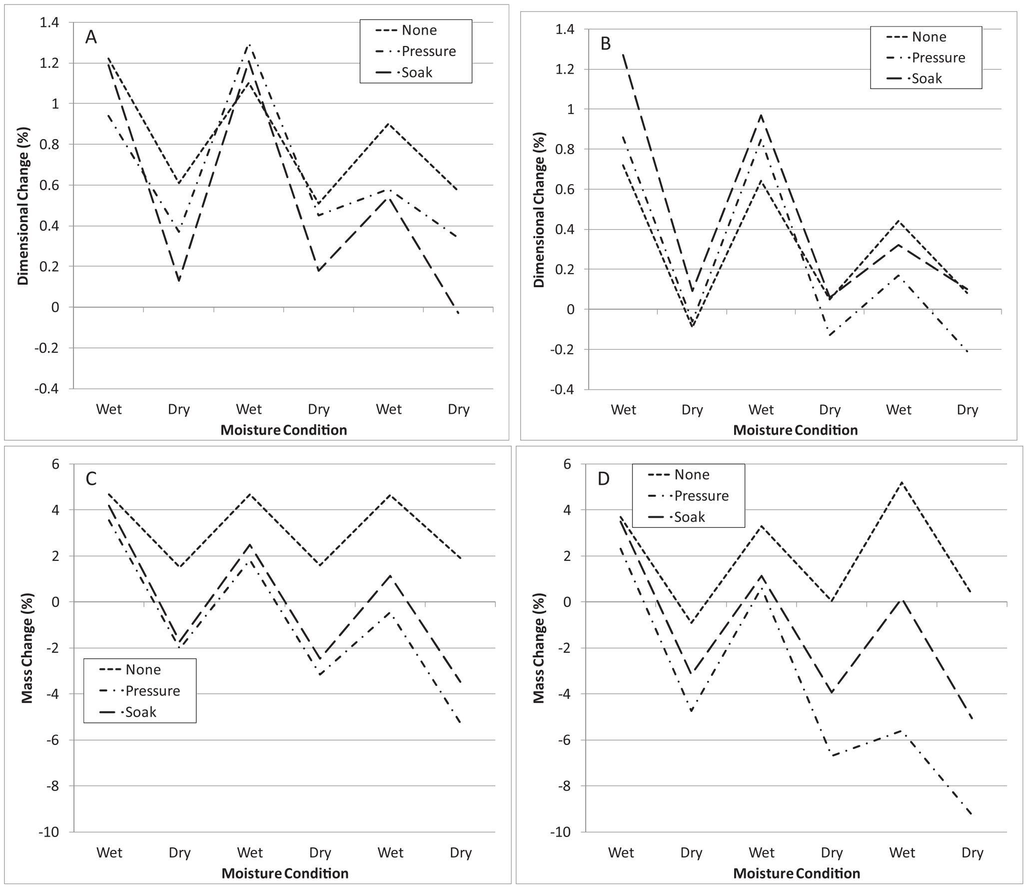

Figure 3.—Effect of soaking or pressure treatment of ponderosa pine lumber that was either treated in the ovendried state (A and C) or treated after soaking (B and D) with a silica/paraffinic-based solution on changes in dimension (A and B) or mass (C and D) during cyclic moisture changes. Values represent means of eight samples per treatment. Wet signifies exposure at 32°C/90 percent relative humidity (RH), while dry signifies exposure at 23°C/65 percent RH.

our procedures, and this process also creates the potential for silicone loss. Our procedures did not involve liquid water but instead depended on vapor diffusion into the specimens. The more subtle wood/moisture interactions may have altered the effects of the silicon or delayed any responses. Thus, further moisture cycles may be required to better delineate the effects of treatment on moisture behavior. These results suggest more fundamental changes in cell wall behavior. Additional studies to better understand possible causes would include a more detailed examination of the relationship between mass change and cell dimensions. However, the material used in this study was not sufficiently selected to allow us to distinguish between individual board variations and mass changes over time. It would also be useful to examine changes in cell wall dimensions following treatment and then over multiple moisture cycles to determine if dimensions change with cycling; however, this was well beyond the scope of this work.

Conclusions

Although there were some inconsistent responses among species, silicon/paraffin treatment appeared to produce a steady improvement in resistance to moisture uptake and swelling for Douglas-fir, ponderosa pine, and red oak lumber. The effect was observed for wood treated while both wet and dry and suggests that these systems have the potential for limiting cyclic moisture changes in wood associated with varying relative humidities. These effects may limit the potential for physical damage to the wood.

Literature Cited

Donath, S., H. Militz, and C. Mai. 2006. Creating water repellent effects on wood by treatment with silanes. *Holzforschung* 60:40–46.

Lukowsky, D., R.-D. Peek, and A. O. Rapp. 1997. Water-based silicones on wood. Document No. IRG/WP 97-30144. International Research Group on Wood Preservation, Stockholm. 11 pp.

Mai, C. and H. Militz. 2004a. Modification of wood with silicon compounds: Inorganic silicon compounds and sol-gel systems. *Wood Sci. Technol*. 37:339–348.

Mai, C. and H. Militz. 2004b. Modification of wood with silicon compounds: Treatment systems based on organic-silicon compounds—A review. *Wood Sci. Technol*. 37:453–461.

Schneider, M. H. and K. I. Brebner. 1985. Wood-polymer combinations: The chemical modification of wood by alkoxysilane coupling agents. *Wood Sci. Technol*. 19:67–73.

US Department of Agriculture (USDA). 2010. Wood handbook: Wood as an engineering material. General Technical Report FPL-GTR-190. USDA Forest Products Laboratory, Madison, Wisconsin. 509 pp.