A Note on the Effect of Wood Moisture Content and Clear Coating on the Color of Veneer Panels Stained with Solvent-Borne Stain

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Abstract

Red alder, mahogany, maple, white oak, and pine veneer panels conditioned to 6, 12, or 20 percent moisture content (MC) were stained with red solvent-borne stain, partially coated with clear lacquer, and air dried. All of the hardwood panels stained at an MC of 20 percent were either significantly redder or darker than panels stained at lower MCs. Clear coating made panels darker and redder (except oak). We conclude that large departures from the recommended MC for staining (6% to 8%) can significantly alter the color of hardwood veneer panels stained with solvent-borne stain.

The staining of wood with solvent-borne stains is an important part of the finishing of furniture, and in 2009 over 2.8 million liters of interior solvent-borne stains were used in the United States (US Census Bureau 2010). Staining can be used to give wood a more attractive even color that mimics the color of more expensive woods (Newell and Holtrop 1961). Once this has been achieved, the color needs to be reproducible within and between stained pieces by carefully controlling the staining process. Reproducing exactly the same color during the staining of wood, however, is difficult in practice. Variation in the color of stained wood can be reduced by applying a sealer before staining to reduce differential absorption of stain or by restaining pieces, which can involve applying stain between coats of lacquer (glazing) or applying a tinted lacquer to the wood (toning). These additional finishing steps allow furniture manufacturers to control wood color, but they also increase the overall complexity and cost of finishing.

Controlling color and minimizing color variation is also important in other industries. The textile industry in particular has carried out research on the factors affecting the dyeing process to better control the color of dyed fabric (Adamiak et al. 2001). One factor that has been shown to have an important effect on the color of dyed textiles is the moisture content (MC) of the yarn. Moisture-sensitive yarns such as wool can show differences in MC of up to 8 percent when atmospheric relative humidity (RH) changes from 40 to 80 percent (Adamiak et al. 2001). Changes in the MC of wool before dyeing can create noticeable differences in the color of dyed yarn that exceed commercially acceptable tolerances (Adamiak et al. 2001). Wood is also a moisture-sensitive material, and its MC can change significantly as a result of fluctuations in atmospheric RH (Millett 1951). Accordingly, we hypothesize that changes in the MC of wood before finishing will alter the color of the stained wood. An increased understanding of factors affecting the staining of wood could lead to better control of the staining process and less variation in the color of stained wood and possibly lower manufacturing costs due to prevention of defects and restaining.

Materials and Methods

Forty veneer panels overlaid with red alder (*Alnus rubra* Bong), mahogany (*Swietenia* sp.), maple (*Acer* sp.), white oak (*Quercus* sp.), or pine (*Pinus* sp.) veneers (eight panels per species) were donated by Pacific Rim Cabinets, Delta, British Columbia, Canada. Panels were sanded with 120, 150, and 180 grit aluminum oxide paper using a wide-belt sander and then cut into three specimens, 10 by 10 cm square (120 specimens in total). Specimens were placed in three different chambers and conditioned to 20 percent (high), 12 percent (medium), or 6 percent (low) MCs (Table

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Table 1.—Target and actual moisture contents of veneer-faced panels after conditioning.

Target MC (%)	Temp (°C)	RH (%)	Actual MCs of conditioned specimens (%)[a]				
			Alder	Mahogany	Maple	Oak	Pine
20	25	85	18.4	18.5	17.4	18.7	19.2
12	20	65	10.6	8.7	12.0	9.6	12.5
6	25	35	6.6	5.7	6.7	6.4	7.3

[a] Values are the means of eight individual specimens.

1). The specimens were removed from the conditioning chambers after they had reached an equilibrium MC, and immediately stained with a red solvent-borne (mineral spirits) wiping stain (Fruitwood, S64N23, Sherwin Williams, Vancouver, British Columbia, Canada). This stain had a viscosity 0.016 Pa·s and a solid particle content of 29.66 percent. Stained specimens were air dried overnight and one-half of each of the stained specimens was sprayed with two coats of an air-curing clear lacquer (Mohawk clear satin catalyzed lacquer, M102-0412). Finished specimens were conditioned at 20 ± 1°C and 65 ± 5 percent RH for 2 weeks to allow the lacquer to cure and the specimens to equilibrate to similar MCs. The color of the stained and coated areas was measured with a spectrophotometer and is expressed using the a* (redness, −60 = green to +60 = red) and L* (0 = black to 100 = white) coordinates of the CIE L*a*b* space system (Adamiak et al. 2001).

The hierarchical design of the experiment accounted for random variation (between boards and specimens) and the fixed effects of MC, wood species, and clear coating on color. Analysis of variance was used to examine the significance of these fixed effects and random factors on the color of stained wood. Statistical computation was performed using Genstat 11. Statistically significant results

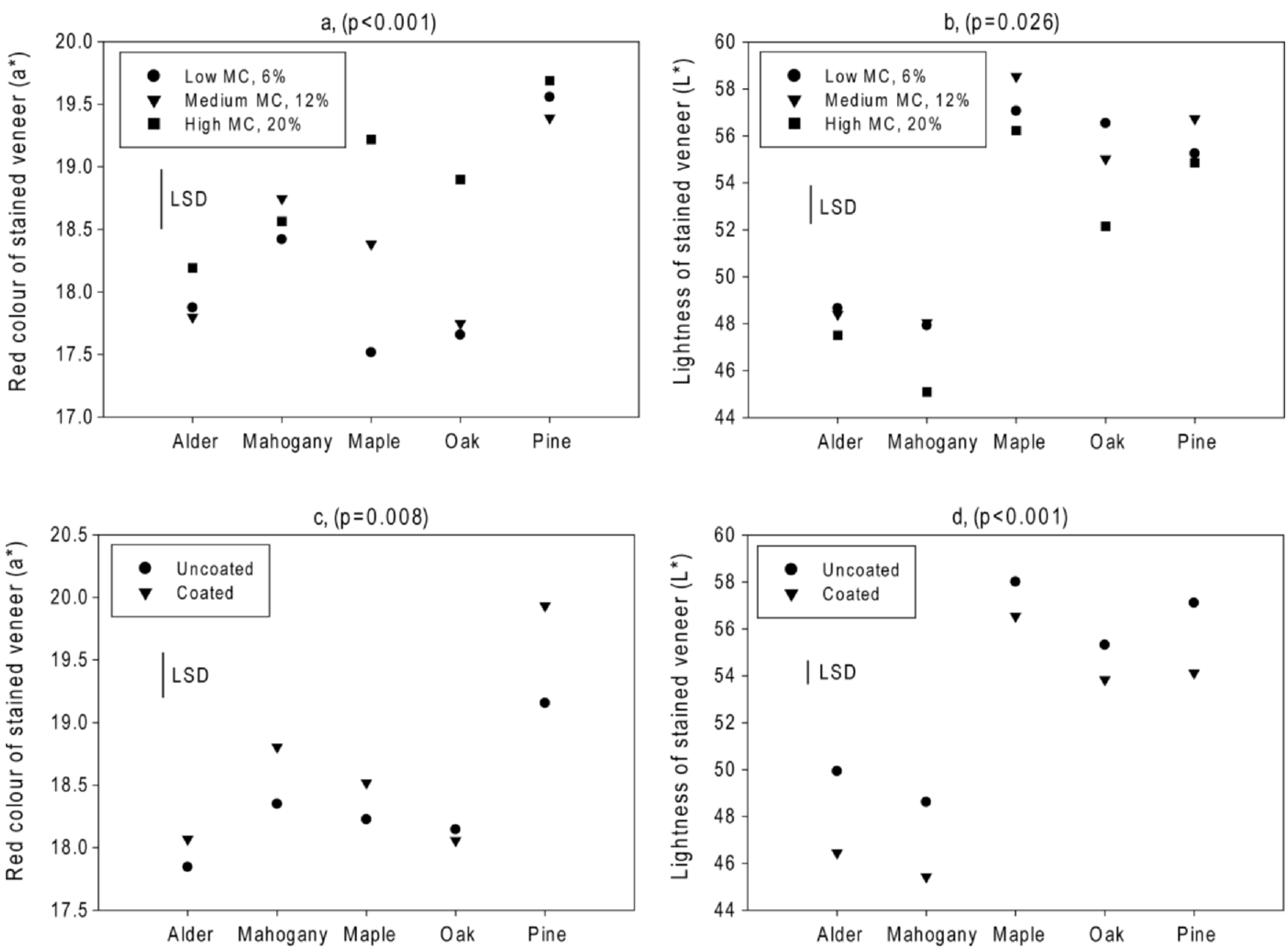

Figure 1.—Effect of wood moisture content (a and b) and clear coating (c and d) on the color of veneer panels stained with red solvent-borne wiping stain. (a) Red color of veneer panels conditioned to different moisture contents, expressed using the CIE parameter a. (b) Lightness of veneer panels conditioned to different moisture contents, expressed using the CIE parameter L*. (c) Red color of coated and uncoated veneer panels. (d) Lightness of coated and uncoated veneer panels. Results in a and b are averaged across coated and uncoated panels, and results in c and d are averaged across panels with different moisture contents because there was no statistically significant MC × species × clear coating interaction.*

are presented graphically and an error bar on each graph can be used to compare differences between individual means.

Results and Discussion

Wood MC, species, and clear coating all had statistically significant ($P < 0.001$) effects on the color of the finished veneer panels. There were also highly significant interactions of MC $\times$ species and species $\times$ clear coating on the color of stained veneer panels. Maple and oak panels conditioned to a high MC of 20 percent before staining were significantly ($P < 0.05$) redder than panels conditioned to lower MCs (Fig. 1a). A similar, but smaller, effect of MC on the redness of stained alder panels was observed (Fig. 1a). In contrast, the redness of stained mahogany and pine panels conditioned to high MC before staining were similar to those of panels conditioned to lower MCs (Fig. 1a). Mahogany, maple, and oak veneer panels conditioned to 20 percent MC before staining were significantly ($P < 0.05$) darker than those conditioned to lower (6% or 12%) MCs (Fig. 1b).

The effect of clear coating on wood color varied with species as indicated by the significant species $\times$ coating interactions on both the redness ($P = 0.008$) and lightness ($P < 0.001$) of veneer panels. For example, coating significantly ($P < 0.05$) increased the redness of mahogany and pine (Fig. 1c), whereas it had no statistically significant effect ($P > 0.05$) on the redness of the other three species. Clear coating significantly ($P < 0.05$) darkened stained veneer panels for all species, but this effect was greater in alder, mahogany, and pine than in maple and oak (Fig. 1d). These effects of clear coating on wood color support the commercial practice of clear-coating the stained sample panels that are shown to consumers to indicate the likely final color of finished furniture and cabinets.

The stain used here is recommended for use at a wood MC of 6 to 8 percent. A departure from this MC to 12 percent did not have statistically significant effects on the color of stained wood, except for redness in maple. In contrast, larger departures from the recommended MC for staining from 6 to 8 percent to 20 percent had significant effects on either the redness or lightness of stained specimens in all species, except for pine. The MC of air seasoned wood in the Pacific Northwest of North America can vary from 13 percent in summer to 22 percent in winter and much lower MCs of 4 to 6 percent have been recorded for wood stored indoors (Millett 1951). MC differences of this magnitude in veneer panels are likely to influence the color of the stained wood and produce seasonal variation in the color of finished wooden furniture components. Hence, our results suggest that companies that require a high degree of reproducibility of color between batches of furniture and cabinets should take care to ensure that the MC of their wood components does not greatly exceed the recommended wood MC for staining.

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