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STUDIES ON THE LOSS OF GLOSS OF SHELLAC AND POLYURETHANE FINISHES EXPOSED TO UV

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ABSTRACT

Wood finishes protect the surface of wood from external agents, enhance its looks and improve its gloss (luster). On constant external exposure, UV rays gradually degrade the film coating resulting in loss of gloss. In this study, two commonly used finishes namely spirit shellac and polyurethane finish were used to investigate the pattern of loss of gloss due to UV interference. Two coatings of polyurethane (PU) and spirit shellac finish were applied on the surface of eucalyptus samples. The gloss levels of these and unfinished samples were monitored for different times of exposure of them to UV light. Gloss was measured at 600 gloss head using a Tri micro gloss meter regularly for 20 hours durations of UV exposure. Observations and analysis revealed that the natural gloss of uncoated samples of eucalyptus were least affected on UV exposure with only 8,3%-10% loss in gloss. The PU and shellac coated surfaces also showed very little reduction in gloss (6,9%-15,4%) most of which happened in the first 40 hours of exposure. Thus both the finishes in this study were found effective to a good extent in maintaining the gloss of the finished surface against exposure to UV light.

Keywords: Eucalyptus, gloss, polyurethane, shellac, ultraviolet.

INTRODUCTION

Wood is a widely used construction material since prehistoric times for both interior and exterior applications because of its pleasant appearance, ease of working, availability and strength. In spite of all these advantages, wood being a biological material is prone to degradation by weathering agents, viz: moisture, light, abrasion. To minimize degradation of wood from weathering agents several methods (surface coating, chemical modification and impregnation with chemicals) can be adopted: among these, wood coating by application of wood finish on the wood surface is the most commonly used method (Black and Mraz 1974, Feist and Hon 1984, Evans *et al.* 2002, Evans 2009). Wood finishes add beauty, provide protection to wood surface from weathering agents viz: heat, light, temperature, moisture, wind, abrasion and provide a cleanable surface. It adds beauty by enhancing its aesthetic value and improving its luster also known as gloss. Gloss is an aspect of the visual perception of objects. It is an attribute of finished surfaces that gives them shiny or lustrous metallic or matt appearances. Commonly used finishes on wood include spirit shellac (natural polymer) and polyurethane (artificial polymer) finish. Polyurethane (PU) is a very tough and durable finish. It is a slow drying finish and compared to other finishes it forms a harder, tougher and more water proof film. Spirit shellac is a quick drying and transparent finish. Unlike PU, it does not form a hard or water proof film. With time, wood products exposed to external conditions often tend to lose the shine or gloss in a definite pattern due to interference of harmful ultraviolet UV radiation reaching the earth's surface. UV rays degrade the film (coating) gradually resulting in a reduction of gloss on surface. UV light causes photochemical degradation

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mainly in lignin polymer in the cell wall. As the lignin is degraded, water leaches out degradation products and washes away loosened surface cellulose fibers, causing a rough surface (Feist *et al.* 1991). The polymers in many surface coating materials have high UV absorption power. The absorbed energy is often sufficient to break molecular bonds. Thus, most of the wood coating materials are expected to be degraded by UV exposure. Both UV-stabilized and non-UV stabilized clear polymeric films are known to suffer a substantial loss of gloss after exposure to UV radiation (Wernsath 1996). UV light is reported to significantly degrade biological stains in wood species such as the red stain of Acer negundo (Robinson *et al.* 2013).

Against this background, a study was undertaken to assess the gloss reduction due to UV exposure of PU and spirit shellac polishes on eucalyptus wood surface and compare the performances of these finishes with respect to gloss reduction. Presently, eucalyptus is emerging as a potential timber species as it is fast growing and possesses good strength. It is raised in plantations and has effectively replaced the need of traditional timber species for furniture, veneer, pulp and paper.

MATERIALS AND METHODS

For this study, seasoned and planed planks of eucalyptus were used. The planks were planed both sides on a planer machine and were cut into samples of size 8” × 3” × ¾” using a circular saw. The cut samples were sanded on one side on a belt sander with 80 grit size to obtain smooth surfaces. Further smoothening was done manually with a 120 grit size sand-paper.

Nine samples were prepared and divided into three groups. Three samples each for PU finish, spirit shellac and the remaining three were used as controls. The samples were numbered accordingly. A commercial polyurethane finish was readily available in the laboratory. Shellac polish was prepared by adding 50 grams of shellac in one litre of spirit and mixing well. The coatings were applied on samples manually with the help of a muslin cloth. It was ensured that the surrounding was dust free for polishing and subsequent curing. After first coating, the surface of the samples was sanded lightly. Two coatings of each of the finish were applied to the surface. The drying time for polyurethane finish was 5-6 hours and that for spirit shellac was less than an hour.

Gloss measurements in the study were carried out at 600 gloss head using a Tri micro gloss meter. The gloss meter was calibrated each time before taking the reading. Gloss values on surfaces of raw samples were also recorded. Several readings were taken on each surface and the mean values were calculated.

All the nine samples were placed in a UV chamber having a UV source (30 W, 254 nm) and were exposed for a brief period of 3 minutes (0.05 hour) and gloss values were recorded. These values were used as the initial gloss of the samples. The samples were then exposed to UV light in the chamber and gloss values were measured after every 20 hours of exposure to understand the gloss reduction pattern. Readings were taken up to 120 hours.

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After completion of each exposure time, the gloss values were tabulated and reductions in the gloss values were calculated as the difference between the initial and the final values for each time period. The percent reductions in the gloss values were also calculated to understand the pattern of gloss reduction under UV exposure.

One-way ANOVA was adopted to test the significance in the differences of percent reduction of gloss. Appropriate transformations were adopted for the percent reduction values before running the ANOVA.

RESULTS AND DISCUSSION

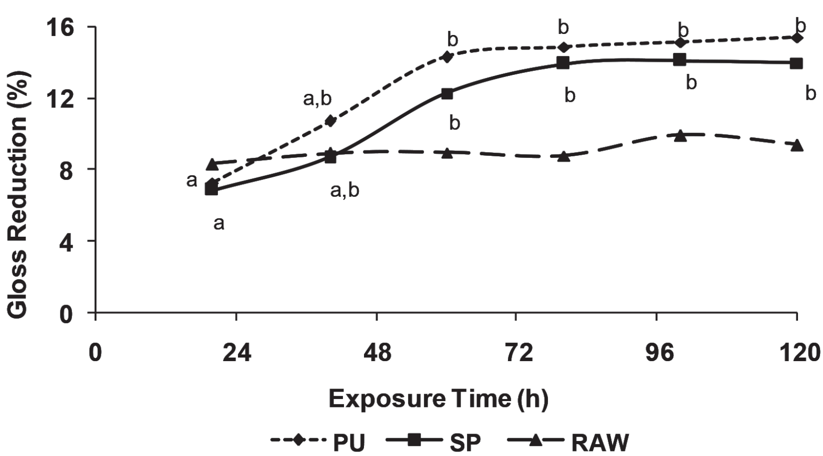
Table 1 gives the average values of gloss measured on the three surfaces after various exposure times.

Table 1. Average gloss values measured on the sample.

Finish	0.05 (h)	20 (h)	40 (h)	60 (h)	80 (h)	100 (h)	120 (h)
Uncoated	4,3 (20,5)	3,9 (21,0)	3,9 (22,6)	3,9 (22,8)	3,9 (22,8)	3,9 (24,4)	3,8 (21,7)
PU	43,5 (15,2)	41,3 (15,4)	40,2 (15,5)	38,5 (15,8)	38,2 (16,4)	38,1 (16,4)	38,0 (16,4)
Shellac	42,2 (9,9)	39,3 (8,5)	38,5 (7,4)	36,9 (7,1)	36,2 (7,1)	36,2 (7,3)	36,2 (7,4)

Note: Values in parentheses show the coefficient of variation (%)

The percent reductions in gloss of each sample due to exposure were calculated and means were estimated. The average calculated percentage reductions are shown in Figure 1.



Note: PU – PU coated samples; SP – Shellac polish coated samples: RAW – Uncoated samples
Gloss reductions values followed by the same letter are not significantly different at the 5% probability level
Figure 1. Mean Percentage reductions in gloss due to exposure to UV light.

The gloss values of the individual samples ranged from 2,8 to 5 GU for the uncoated samples showing very little gloss for the natural sanded surface of Eucalyptus. The ranges were 31,7 to 50,8 GU for the PU coated samples and 33,3 to 46,1 GU for the shellac coated samples after different exposures to UV light. The highest gloss values are obviously for the measurements made on the samples after giving them a slight exposure of 3 minutes. One can see from table 1 that both the shellac and PU coated samples showed comparable glosses and started losing the shine gradually as they continued to be exposed to the UV light. This reduction is slow for the very low gloss uncoated surface. The initial low gloss values of raw samples demonstrate the importance of polishing the surface of a wooden product to enhance the show-room value of the product. The fact that the available low shines of uncoated samples also get reduced by UV exposure illustrates that unfinished wood surfaces exposed to weather/ UV are roughened by photo degradation and undergoes subsequent erosion (Feist 1988).

However, being organic in nature, the coatings that one applies to the wood surfaces are also prone to this photo degradation causing slow erosion. On the other hand, they do protect the actual wood surface from getting eroded through photo-degradation (Williams 2010). The ability to withstand the effect of UV exposure was studied through calculating the percent loss in gloss of each sample. On an average, the uncoated (RAW) samples lost about 8,3 to 10 % of the initial gloss. On the other hand the coated samples showed reductions in the range of 6,9 to 15,4 % of the initial values. Figure 1 shows that the shellac coated samples show marginally lower reductions compared to PU coated samples. It also shows that the gloss reductions are faster during the first 60 hours and thereafter the reductions become very gradual.

To understand the time dependence of the gloss reduction percentages, the percent reduction data were analysed using one-way ANOVA. Since the individual gloss reduction percentage values were low, all the data were transformed to their square roots before running the ANOVA (Ahrens *et al.* 1990). The results of the analysis are presented in table 2.

Table 2. One-way ANOVA results on gloss percent reductions after different exposure times after square root transformation.

Polish used	Source	Sum of Squares	df	Mean Square	F	Sig.
PU	Time	3,758	5	0,752	5,295	0,009
	Error	1,707	12	0,142		
	Total	5,465	17			
Shellac	Time	3,738	5	0,748	6,393	0,004
	Error	1,407	12	0,117		
	Total	5,145	17			
Raw (unpolished)	Time	0,127	5	0,0253	0,218	0,948
	Error	1,393	12	0,116		
	Total	1,520	17			

It can be seen from table 2 that exposure time does not have any significant effect on the gloss reduction of uncoated samples. However, the coated samples (both PU coated and shellac coated) show a time effect. Figure 1 suggests that the coated samples lose the gloss initially up to about sixty hours at a faster rate and thereafter the gloss reduction appears to be rather slow. To understand this, subsets of the transformed gloss reduction percentage data were compared on SPSS software using the Student-Newman-Keuls (SNK) method. The results grouped both the coated samples into two subsets each (Figure 1). In each case reductions after 20 and 40 hrs are grouped together indicating that the coatings actually lost their glosses mostly in the first

40 hrs and in similar fashion. Thereafter, the loss of gloss is rather uniform till the end of the experiment. Hence, the UV degradation as far as the gloss is concerned happens mostly in the initial period of exposure.

To understand the difference in loss of gloss behavior between the coatings, the data was analysed for each exposure time. For any exposure time, there were no significant differences between gloss reductions between the two finishes studied.

CONCLUSIONS

The gloss of the unfinished eucalyptus surface was not affected by exposure to UV light. However, though not hugely, both the PU and shellac surface coats showed reductions in gloss after exposure to UV light. Most of this reduction occurred in the first 40 hours and thereafter, the reductions were not significant. Thus, both the coats studied seem to be quite resistant to UV light as far as loss of gloss is concerned under the UV exposure conditions used in this study.

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