Ciência da Madeira (*Brazilian Journal of Wood Science*)
7(2): 94-99, 2016
DOI: 10.12953/2177-6830/rcm.v7n2p94-99

Recebido: 13-12-2015 Aceito: 17-08-2016

Gloss of four common wood coatings measured before and after their exposure to high humidity

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ABSTRACT Value addition through a shining appearance is often important for wood products which can be brought about by glossy surfaces provided by suitable coatings on them. The gloss and gloss retentions of four common wood coatings were investigated in this study on *Melia composita* wood substrate, before and after exposure to high humidity. Lacquer gave the highest and melamine the lowest gloss initially. On exposing the coated samples for 25 days to 90% relative humidity, melamine coated samples registered a loss of only 12%-16% of its initial gloss. Lacquer, nitrocellulose lacquer and polyurethane coated samples could retain only 60% of their initial gloss. The study illustrated the weather-resistant properties of melamine as a top coat as far as gloss is concerned.

Keywords: Gloss, Melamine, *Melia composita*, Lacquer, Polyurethane, Aging.

Introduction

Wood finishes improve aesthetics and provide a cleanable and protected surface to weathering agents such as heat, light, temperature, moisture, wind and abrasion. Finishing can add beauty by enhancing the aesthetic value of wood and improving its luster, also known as gloss. It is an attribute of finished surfaces that gives them shiny or lustrous metallic or matt appearance.

Gloss is one of the aesthetic properties of a coating. It is based on the ability of a surface to reflect directed light (ZIVKOVIC, 2004). This property often finds importance in the quality evaluation of a product, especially where the aesthetic appearance of the product is important.

Among the most common wood coatings, polyurethane (PU) is hard, abrasion-resistant and durable, and is known to act as a good moisture barrier for wood based products (POATY et al., 2013). Carter (2012) cited good mechanical strength and adhesion as well as ease of multiple coating layers as advantages of PU-based varnishes. In spite of the above advantages, PU based finishes are not very much favored for outdoor uses since they are prone to UV degradation (KURTOĞLU, 2000).

Another wood coating is melamine, which is also a popular industrial product due to its chemically stable structure (KANDELBAUER; WIDSTEN, 2009). However, most of the research in the field of wood utilization has been to treat solid woods with melamine compounds. There are reports of the ability of water-based melamine presenting good resistance when subjected to wood-decaying fungus and its weathering performance (LUKOWSKY et al., 1999; RAPP; PEEK, 1996; PITTMAN et al. 1994; RAPP; PEEK, 1999). Penetration of N-methylol-melamine molecules into the cell walls of the solid wood has been credited as the reason to the resistance against photodegradation (HANSMANN et al., 2006).

Nitrocellulose lacquers can result in a very hard, flexible and durable finish on wood surfaces (CAKICIER et al., 2011), which is now widely used by the solid wood industry. Niimura (2014) considers lacquer as a good coating material for wood due to its ability to cure into a tough film with resistance to temperature. Lacquers have the capacity to penetrate into

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wood substrate sometimes even better than oil finishes (ROBINSON et al., 2013). Though preferred by the wood coating industry, lacquers are generally considered hazardous due to the flammable and volatile nature of the solvents used (KURTOĞLU, 2000).

Since the wood of *Melia composita willd.* (Synonym *Melia dubia)* seems to be a good candidate as a useful timber, its finishing properties are important. Nevertheless, from the finishing point of view, this wood was not fully explored. The wood of *M. composita* has diffuse porous structure (SARAVANAN et al., 2013a). Koul et al. (2000) reported the biopesticidal properties of this species. Saravanan et al. (2013b) found this species suitable for paper pulp production. Studies on mechanical, gluing and bonding properties showed that this species is a good candidate for the plywood industry as well (SARAVANAN et al. 2014; UDAY et al. 2012). Studies on finishing properties using common coating materials would help in the value addition of solid wood products made out of *Melia composita*. This study was performed to understand the gloss behavior of four types of coatings (lacquer, nitrocellulose lacquer, melamine and polyurethane) on the surface of *Melia composita* wood when exposed to high humid conditions.

Material and Methods

Forty samples measuring 20 cm x 7.6 cm x 1.65 cm were prepared from plain sawn *Melia composita* wood planted in a mixed forest. All these samples were uniformly sanded with sandpapers with grit sizes of 80, 100 and 120 in progressive order. After smoothing the surfaces, all wood samples were kept in a controlled humidity chamber (35ºC of temperature and 30% of relative humidity). The weights of wood samples were monitored until they achieved constant values.

The four commercial polishes (Lacquer-L, Melamine-M, Polyurethane-PU and Nitrocellulose Lacquer-NCL) were applied by brush to the surfaces of 40 samples (10 samples per finish) with four successive coats for each polish. It was ensured that successive coats were applied only after the preceding coat dried in a dust free environment.

All samples were again conditioned in the humidity chamber. After the conditioning, the gloss values were measured using a TriMicro gloss meter with 60-degree gloss head (SEN, 2000). Ten random readings were taken for each wood sample.

Thereafter, the relative humidity in the climatic chamber was raised to 90% without altering the temperature. The samples were kept in this high humidity condition during 25 days (600 hours). At the end of 25 days, the samples were taken out and their final gloss were measured as described above.

The percent reductions in gloss (GR) were calculated for each of the four polishes using Equation 1.

$$GR = \frac{(IG-FG).100}{IG} \qquad \text{Equation 1}$$

Where: IG and FG are the initial and final gloss (GU), respectively.

SPSS package was used for testing normality of data through Shapiro-Wilk test and one-way analyses of variances (ANOVA) and Duncan's homogeneous subsets were used to understand the performance of individual coatings.

Results and Discussion

The Shapiro-Wilk test performed on the initial gloss, final gloss and gloss reduction percentage data for each coating showed that they are normally distributed in each case. The significance levels varied between 0.080 and 0.999 for different parameters.

The mean initial gloss values ranged from 60.5 GU for melamine to 124.7 GU for Lacquer. These are shown in Figure 1. The error bars indicate the coefficients of variations (CV%) of the means.

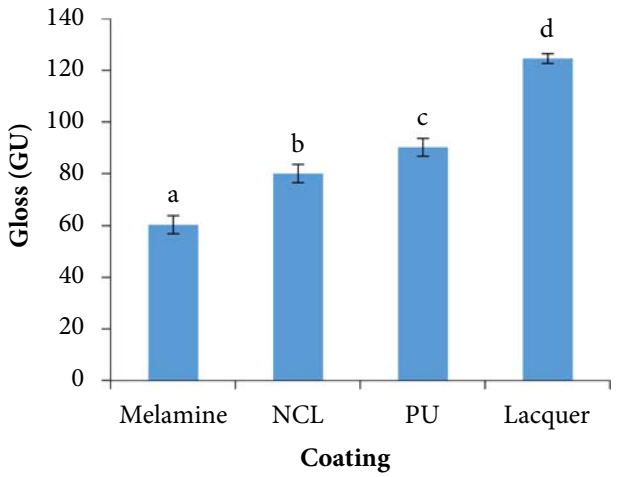

Figure 1. Mean initial gloss values of the four coatings used (Note: Different alphabets on the bars define different significant levels).

Figure 1 suggests that the initial gloss values show a trend with melamine and lacquer being at the lowest and highest values respectively. PU seems to have a slightly better gloss than NC lacquer. To understand the actual differences in initial gloss pattern, the actual values of individual samples were analyzed through one-way ANOVA which indicated that the values have significant differences ($p<0.001$). To investigate the actual pattern, Duncan's subsets were formed with the Initial gloss values. This analysis clearly distributed the gloss values of the four coating materials into four subgroups in the order melamine<NCL<PU<Lacquer. Thus, each of the finish material studied results in different gloss levels initially on this wood surface. Except for melamine, the other three coatings yield high gloss values (> 70 GU).

Bio-based PU coating presented a gloss average value of 95% when measured at 60° (DANILIUC et al., 2012). However, Rajput et al. (2014) reported gloss of 50-58% for two types of bio-based PU coatings. The gloss levels reported for PU and melamine on veneers of Teak are 93-95 GU and 88-90 GU respectively, but after very different surface treatments (PANDEY et al., 2007). The values on *Eucalyptus tereticornis* surface following the same surface treatments were 93-95 GU and 90-92 GU respectively. In either case, the coats were sprayed onto the substrates. The initial value of PU (90.3 GU) in the present study is not very far from those reported on teak and *E. tereticornis*. It is to be noted that melamine indeed gives lower gloss values as in the case of Teak. One of the reasons for the high gloss of lacquer could be its ability to penetrate deeply into the wood substrate as reported in the case of different wood species (*Acer negundo, A. saccharum, Populus tremuloides* and *Tilia americana*) through scanning electron microscopy (ROBINSON et al., 2013). The four coats of lacquer applied must have formed a thick lustrous film.

The mean final gloss values obtained after 25 days of exposure to high humidity ranged from 47.8 GU for NCL to 77.8 GU for Lacquer (Figure 2). The error bars indicate the coefficients of variations (CV%) of the means.

Figure 2 reveals that, in general, 25 days of exposure to high humidity have brought down the gloss values. However, this reduction was not uniform. Melamine, which had the lowest initial gloss, retained a good gloss even after exposure. Melamine shows 51.7 GU from its initial 60.5 GU. However, NC lacquer seems to be the poorest in retaining the gloss. It came down from its initial value of 80.1 GU to 47.8 GU due to exposure. It would be interesting to see if these final values of the four coating materials differ significantly. The ANOVA of the final gloss values revealed that values differ significantly for the four finishes studied ($p<0.001$). To understand the pairwise difference, Duncan's subsets were formed for the final gloss. Unlike in the case of initial gloss, the final values were grouped into 3 groups with Melamine and NCL occupying the lowest valued group. Their gloss levels dropped to

50.4 GU and 47.8 GU respectively after exposure. PU and Lacquer, despite having retained their top gloss positions, lost their initial shine quite considerably. Because of the dissimilar gloss reductions observed, it would be very interesting to look at the actual reduction percentages (Figure 3). The error bars indicate the coefficients of variations (CV%) of the means.

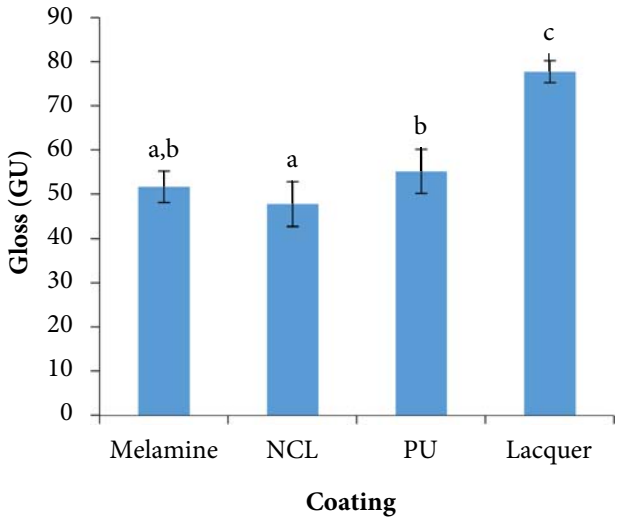

Figure 2. Final gloss after exposure to high humidity for 25 days (Note: Different alphabets on the bars define different significant levels).

To understand the actual behavior in the gloss reductions, the reduction percentage values were analyzed. The actual values ranged roughly between 12% and 50%. Hence, arcsine transformation was adopted before running the ANOVA (AHRENS et al., 1990). The results of the ANOVA revealed significant differences in the reduction pattern ($p<0.001$). The individual behavior was assessed by forming Duncan's subsets with the transformed reduction percentage values. Very interestingly, the GR values were grouped only into two subsets with melamine alone occupying the lowest valued group with a mean 16.8% reduction in gloss. All the other three coatings are shown to lose their gloss

equally (37.6 to 40.5%). Thus, melamine seems to be more weather resistant. In fact, it is the stable structure of melamine which

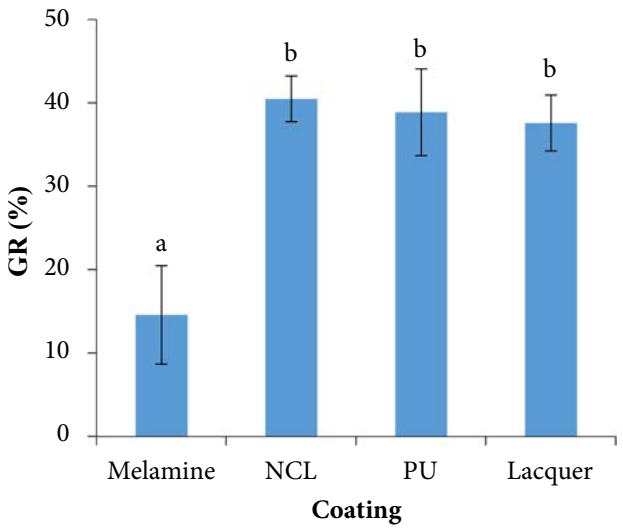

Figure 3. Gloss reduction percentages of the four coating materials (Note: Different alphabets on the bars define different significant levels).

makes it a good industrial coating material (KANDELBAUER; WIDSTEN 2009). Treatments with Melamine compounds are also reported to improve the natural weathering performance of plywood made from *Fagus sylvatica* (TRINH et al., 2012). There are reports on at least water-based lacquers having less resistance in gloss and adherence when applied on wood substrates (YAKIN, 2001). The use of organosilane is reported to enhance gloss retention in paints (MATERNE et al., 2012). However, PU and melamine when stored at ambient conditions lost only 0-2% gloss (PANDEY et al., 2007). Thus, the present study illustrates the effect of artificial weathering of PU at high humidity. The extent of gloss reduction in PU coated samples of eucalypts was about 15% after 120 hours of UV exposure (GHOSH et al., 2015). NC lacquer applied on heat treated wood surfaces showed increased roughness (CAKICIER et al., 2011). Therefore, a considerable reduction in its gloss is expected. The gloss reduction percentage for shellac polish applied on mango wood surface on exposure to 90% humidity for one month is reported to be 30.6% (SAMANI; GUPTA 2010). However, only 26.48% loss of gloss was reported by them on exposure of such samples to

external environment under shade for two years (SAMANI; GUPTA 2011). The study reveals that melamine has the capability to retain most of the initial gloss; however, if one needs a high gloss surface during the service life of a product, it is lacquer which can give good results in spite of its relatively high loss in gloss.

Conclusions

This study of four commercial wood finishes applied on *Melia composita* wood substrate in four coats using brush revealed that melamine results in least gloss values whereas nitrocellulose lacquer, polyurethane and lacquer give values in excess of 70 gloss units. On exposure to high humidity, Lacquer, NC lacquer and PU coated samples lose their initial gloss heavily by around 38% to 40%. The better resistance of gloss of melamine to high humidity was illustrated by its very low gloss reduction in the range of 12% to 16 %.

Acknowledgements

The authors are thankful to Director, FRI, Dehradun for the encouragement and ICFRE, Dehradun for funding this study. The encouragement by Head of Forest Products Division and the help rendered by the staff of Wood Working and Finishing Discipline are acknowledged.

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