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Full Length Research Paper

The effects of protective dye layer applied on varnish layer hardness, scratch resistance and glossiness of various blockboard types

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This study is carried out for determining the changes occurring on the amount of the material used on the protective layer when polyurethane and acrylic (lacquered) dye is applied on the test samples prepared from sandwich type composite (blockboard) boards with their surface coated or uncoated with paper, which are used for the yacht furniture and interior decoration. After applying polyurethane and acrylic dye on the 30 test samples prepared as coated or uncoated with paper with 10 x 10 x 1.6 cm sizes from blockboard, the surface hardness values of the protective layer as applied in ASTM D 4366-95 (1984) were determined, the scratch resistance were determined according to the essentials specified in TS 4757 (1986), and the glossiness were also determined according to the essentials specified in TS 4318 EN ISO 2813 (2002). According to the result of the study, concealing dyeing is obtained with much surface hardness, scratch resistance and glossiness by using less lacquer dye on the boards coated with paper. With this study, it is possible to suggest that coating with paper before lacquer dyeing can be a preferable application in terms of cost and time saving.

Key words: Blockboard, polyurethane dye, acrylic dye, hardness, scratch resistance, glossiness.

INTRODUCTION

Blockboard is one of the best alternatives to plywood, which withstands bending better than plywood. The main advantage of blockboard is that the heart of the board is produced from thick sections of wood and hence a large number of veneers do not need to be manipulated and fabricated, thus reducing cost and manufacturing time. Blockboard is produced from softwood strips placed edge to edge and sandwiched between veneers of hardwood, all being glued under high pressure. Typical applications of blockboard are in manufacturing furniture, backs of cabinets and centre panels for framed doors. Among other items used in building interiors, kitchen cupboards, skins for flush doors, lightweight and decorative doors, partitioning, exhibition paneling, kitchen cabinets, bedroom and dining room furniture, loudspeaker boxes and panel moldings may be manufactured from blockboard (Kartal and Ayrilmis, 2005; Laufenberg et al., 2006).

Use of surface coatings is important for maintaining the appearance and physical serviceability of wood, particularly where exposed to the elements.

Primer is a paint product that allows finishing paint to adhere much better than if it was used alone. For this purpose, primer is designed to adhere to surfaces and to form a binding layer that is better prepared to receive the paint. Because primers do not need to be engineered to have durable, finished surfaces, they can instead be engineered to have improved filling and binding properties with the material underneath. In practice, primer is often used when painting many kinds of porous materials, such as wood. There are several reasons for making the use of a primer before painting wood mandatory. First of all, wood is very porous and will absorb the solvent from paint drying the paint prematurely. Because most paints undergo chemical reactions during the process of curing (for example, latex and alkyd-based paints actually polymerize when curing), they depend on water or solvent being evaporated slowly

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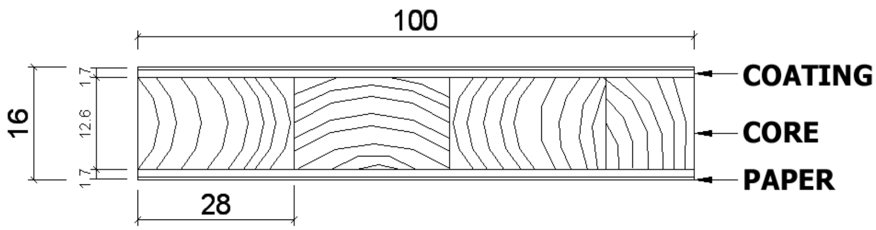

Figure 1. Blockboard sizes (Cakicier et al., 2010).

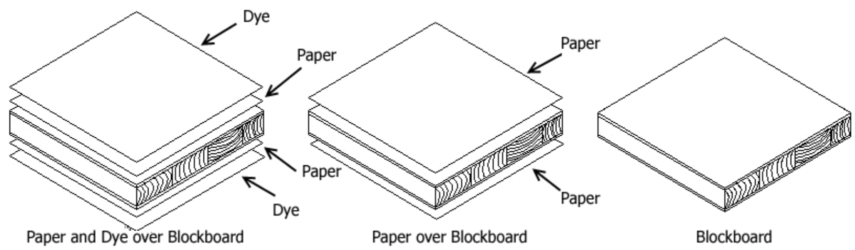

Figure 2. Blockboard layers (Cakicier et al., 2010).

rather than being absorbed quickly by the underlying material. A layer of primer will help the paint to undergo proper complete curing cycle. Secondly, without a primer, several layers of paint can be necessary to completely obscure the wood grain and ensure even color. Lastly, if wood is exposed to moisture, a thin layer of paint will still be water permeable. The final result will be warped parts, mildew, and dry rot. Primer adds to the waterproofness of the paint (Kurtoğlu, 2000; Anonymous, 2011).

Lacquer is often regarded as the best all-around finish for wood. It dries quickly, and it's durable. The finishing industry responded by developing lacquers containing acrylic resins that are truly "water-white." Acrylic resins go on crystal-clear and stay that way over time. Acrylic lacquer is often used as a protective topcoat over colored pigment lacquers to make them wear better and to enhance their resistance to scratches. Polyurethane lacquer is used as decorative and protective for high quality wooden furniture to improve their durability, and high gloss topcoat metal equipment (Kurtoğlu, 2000; Sonmez and Budakçi, 2004).

In this study, the changes, which may occur on the protective layer and in the amount of the dye used when polyurethane and acrylic dye are applied in order to create a protective layer as coated or uncoated with paper on the surface of the sandwich structure composite board (block board) used in furniture and decoration, are determined.

MATERIALS AND METHODS

Blockboard

Blockboard composite board material, a sandwich structure material used in producing yacht furniture and interior decoration furniture, has been chosen as the test material. The test samples are obtained from a private company producing yacht and boat furniture in Turkey imported from Moralt Tischlerplatten GmbH & Co KG Company located in Germany. The samples are prepared with random selection among the boards.

A total of 40 test materials, 10 of which were coated or uncoated with paper prepared by cutting with 0.5 mm sensitivity and with 100x100x16 mm size from blockboard, are prepared (Figure 1).

Fiberboard and MDF with primitive methods used by the furniture makers before, blockboard has been converted into a material more suitable to purpose by using advanced tree technology.

It is produced by coating the sub- and upper surfaces with peeling coating pupil, oven drying its interior with soft trees such as pine, fir and maple and pressing the trees arranged as short and thin laths as end-to-end and next to each other. Melamine and Urea formaldehyde glues (E2 norm) are used in hot press applications (Figure 2).

Coloring materials

During the tests, before applying acrylic white and polyurethane black lacquer on the paperless board, hardener and filling varnish mixture (Sayerlack XT 4028) + varnish (Sayerlack TR 4027) have been applied as barrier layer and dried for 4 h. After leveling the dry layer with no. 220 emery, polyester primer dye (PU-0377-13) has been applied and dried for 8 h. After being leveled with no. 120 and 180 emery, the layer was dyed with primer lacquer dye (Glasurit Universal Primer filler AB 285-650) and dried for 4 h. After the dried layer was leveled with no. 220 and 320 emery, inspection paste (Dyo Polyester Paste) was applied, rubbed with no. 320 and 400 emery, dyed with Glasurit 22 Series Acrylic Finish Mat Dye (Color: White, Code: U8x02x21.50) and dried for 8 h. While applying acrylic white and polyurethane black lacquer on the boards coated with paper, it was applied without barrier layer and polyester primer dye (Cakicier et al., 2010).

Preparation of test samples

Coloring

Coloring treatments were applied with spraying guns on surfaces,

Figure 3. König pendulum hardness.

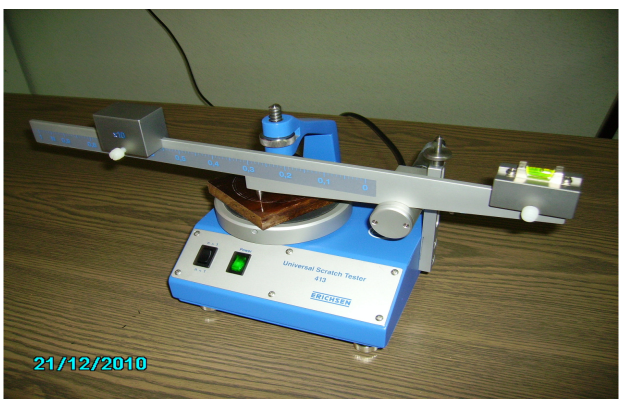

Figure 4. Scratch resistance.

cleaned by brush, considering the recommendations of the manufacturer company. Dye has been applied as 3 layers for boards coated with paper and as 5 layers for board uncoated with paper (Cakicier et al., 2010).

Test method

The varnished samples were dried for three weeks for full curing under laboratory conditions of 20 ± 2°C temperature and 65 ± 5% relative humidity in order to provide full drying. After this, before surface roughness and color differences measurements, the samples were conditioned for 16 h under the air conditioning environment of 23 ± 2°C temperature and 65 ± 5% relative humidity by complying with the basis of TS 642 (1997) and prepared for the tests.

Determination of hardness: Conditioned samples were subsequently subjected to the König pendulum hardness test to detect the hardness of the varnish coating according to ASTM D4366-95 (1984). Test panels were placed on the panel table and a pendulum was gently placed on the panel surface. The pendulum was then deflected through 6° and released while simultaneously starting the oscillation counter. The number of oscillations for the amplitude to decrease from 6° to 3° was determined to be the König hardness. Ten replications were conducted on separate specimens for each treatment group (Figure 3).

The rough drafts for the preparation of test and control samples were cut from the sapwood parts of massif woods with dimensions of 500 mm × 100 mm × 15 mm. Samples with dimensions of 100 mm × 100 mm × 10 mm were cut from the drafts, and a 6.5-mm diameter hole was drilled in the middle for the scratch resistance test.

Determining the scratch resistance: The scratch resistance of the samples after the varnishing process was determined by the tests based on TS 4757 (1986). The scratch tester created a scratch on the sample surface that could be seen with the naked eye using a diamond bit (radius, 0.090 ± 0.003 mm). The diamond bit was placed parallel to the horizontal plain using a spirit level, and the experimental sample was connected to a supporting disc with a pressure screw that works at a speed of 5 ± 1 rotation/min. When the supporting handle with the diamond bit touched the sample, it was brought to a horizontal position, and the experiment started after making adjustments with a sensitivity of ±0.01 N. The experiment started with a 5-N applied force, and if no trace resulted on the sample surface, the applied force was decreased by 0.5-N steps until a continuous scratch was formed. If a continuous scratch was formed with 5N, then the force was decreased to 2N by 0.5-N steps, to 1N by 0.25-N steps, and to 1N by 0.1-N steps. The experiment was concluded when a dotted scratch was formed. After cleaning the sample surface with a soft cloth and alcohol, the surface was checked by eye under 100-lx lamps. The value of the continuous scratch mark before the appearance of dotted scratches was accepted as the sample scratch resistance (Figure 4).

Determining the glossiness: After the treatments applications, using light reflections, sample glossiness were measured with the aid of Picogloss 562 MC gloss meter according to TS 4318 EN ISO 2813 (2002) standards. Ten panels for each varnish type and tree species were used in the experiments, and two measurements, parallel and vertical to the fiber, were made on each sample.

Gloss is a measurement of the light reflectance of a varnish surface. In gloss measurement tests, a beam of light is directed toward the test varnish surface at a certain angle from the perpendicular. The percentage of the beam that is reflected at the same angle is measured by a photocell. Two standard angles are used: 60° for general gloss readings; 85° for sheen readings. Completely specular light reflection (perfect gloss) would be 100%; completely diffuse light reflection (mat or dead flat) would be 0%. The classification of varnishes according to gloss ratings depends on the ability of the surface to bounce back varying amount of light beamed on it, and these readings show the relative reflectivity of the coated surface as compared with a smooth, flat mirror (Figure 5).

Statistic method

For all parameters, multiple comparisons were first subjected to an analysis of variance (ANOVA) and significant differences between average values of control and treated samples were determined using Duncan's multiple range test at P value of 0.05 (Kalipsiz, 1994).

RESULTS AND DISCUSSION

The statistical data of surface hardness, scratch resistance and glossiness values are given in Table 1.

Figure 5. Glossmeter.

Table 1. Statistical data of surface hardness, scratch resistance and glossiness values.

Blockboard type	Units	Hardness (Number of oscillations)	Scratch resistance (N)	Glossiness
Paper over blockboard	Avg.	60.3 defg	6.7 eg	3.70 f
	± s	3.769	0.559	0.272
	s^2	14.2	0.313	0.074
	V	6.253	8.412	7.342
	N	30	30	30
Acrylic lacquer dye + paper over blockboard	Avg.	87.4 bcdefg	8.4 a	6.70 bcdefg
	± s	4.173	0.458	0.230
	s^2	17.41	0.209	0.053
	V	4.776	5.481	3.447
	N	30	30	30
Acrylic primer dye over blockboard	Avg.	52.1 efg	6.4 fg	3.40 g
	± s	2.683	0.397	0.240
	s^2	7.197	0.158	0.057
	V	5.149	6.255	7.031
	N	30	30	30
Acrylic primer + lacquer dye over blockboard	Avg.	90.2 a	8.0 bdefg	6.70 cdefg
	± s	2.914	0.661	0.405
	s^2	8.489	0.437	0.164
	V	3.231	8.316	6.022
	N	30	30	30
Polyurethane dye + paper over blockboard	Avg.	43.1 f	7.6 defg	6.00 defg
	± s	5.929	0.578	0.319
	s^2	35.15	0.334	0.102
	V	13.75	7.65	5.322
	N	30	30	30

Table 1. Contd.

Polyurethane primer dye over blockboard	Avg.	40.6 g	4.8 g	4.00 eg
	± s	4.545	0.612	0.674
	s^2	20.650	0.375	0.454
	V	11.18	12.89	16.950
	N	30	30	30
Polyurethane lacquer dye over blockboard	Avg.	73.3 cdefg	7.8 cefg	7.7 a
	± s	3.513	0.519	0.881
	s^2	4.795	0.269	0.777
	V	30	6.649	11.380
	N		30	30

Number of samples used in each test is 30. Avg. = average; ±s = standard deviation; s^2 = variance. V = coefficient of variation. N= number of samples used in each test. Homogenous groups: letters in each column indicate groups that are statistically different according to Duncan's multiple range test at P < 0.05. Comparisons were between each control and its test.

According to Table 1; it will be seen that there is a statistical difference, with a confidence interval of 95%, between the surface hardness values of acrylic primer + lacquer dye over blockboard samples and the surface hardness values of acrylic lacquer dye + paper over blockboard, polyurethane lacquer dye over blockboard, paper over blockboard, acrylic primer dye over blockboard, polyurethane dye + paper over blockboard and polyurethane primer dye over blockboard samples.

Also, it is seen that there is a statistical difference, with a confidence interval of 95%, between the scratch resistance values of acrylic lacquer dye + paper over blockboard samples and the scratch resistance values of acrylic primer + lacquer dye over blockboard, polyurethane lacquer dye over blockboard, polyurethane dye + paper over blockboard, paper over blockboard, acrylic primer dye over blockboard, and polyurethane primer dye over blockboard samples.

Furthermore, it also observed that there is a statistical difference, with a confidence interval of 95%, between the glossiness values of polyurethane lacquer dye over blockboard samples and the glossiness values of acrylic lacquer dye + paper over blockboard, acrylic primer + lacquer dye over blockboard, polyurethane dye + paper over blockboard, polyurethane primer dye over blockboard samples, paper over blockboard and acrylic primer dye over blockboard samples.

Conclusions

According to the result of the study, concealing dyeing is obtained with much surface hardness, scratch resistance and glossiness by using less lacquer dye on the boards coated used in yacht furniture and interior decoration and with its surface coated with paper.

In the study performed by Kaygin (1997), the acrylic dye has achieved better results compared to cellulosic dye and much better results compared to synthetic dye in terms of the strength against brightness and scratching. It has been reported that despite all these advantages, the cellulosic dye is preferred more compared to the acrylic dye in the furniture industry due to its low cost.

In the study performed by Nemli (2000), it was been determined that there is a significant decrease in the water-taking amount and thickness-increase rate between 2 to 24 h as a result of coating the surfaces of the fiberboard with lacquer dye, melamine absorbed papers, wooden coating boards and roll laminates.

With this study, it is possible to suggest that coating with paper before lacquer dyeing can be a preferable application in terms of costs and time saving.

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