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SHORT NOTICE

THE INVESTIGATION OF BORAX PENTAHYDRATE INFLUENCES WITH DOUBLE COMPONENTS IN VARNISH APPLICATIONS OF WOOD MATERIALS

Murat Ozalp
Dumlupinar University, Simav Technical Education Faculty, Kutahya, Turkey

ABSTRACT

In this study, a different amount of borax pentahydrate is added into cellulose bright varnish, which is used for upper surface treatments of wood materials. The pre-prepared varnish cellulose is implemented on upper surfaces of Austrian pine and beech wood for wood materials. After that toughness, brightness and surface sticking resistance experiments are conducted over these varnish stratums. The effect of the pentahydrate added into the varnish is determined. Consequently, it is determined that the pentahydrate added into the varnish increased the toughness and sticking resistance on both wood types substantially; however, it also decreased the brightness value of the varnish greatly.

KEYWORDS: resistance of stick, hardness, brilliance, varnish

INTRODUCTION

The surface coatings of the wood materials with preservative treatments as a natural raw material are based up to B.C. 200's. Throughout the history, early surface preservative treatments were prepared with wood shell liquids and after that this process has gained new dimensions after natural resins and dried oil began to be used as components (Sonmez 1989).

Numerous types of varnishes and paints are used in Turkey as preservative treatments. Dependent on the difference of the elements used in production of these varnishes, their resistance to different external effects is expected to be different also.

Besides the difference in the preservative materials there may also be some differences in the wood materials used to make furniture. There are some structural differences among different tree types in the frame of their anatomical structure. This difference may also exist among the same kind of woods and even between two different parts of the very same ingot or between the two pieces cropped differently. Considering these, it is estimated that the same kind of preservative material will not provide the same endurance against exterior effects on different kinds of wood; this is also the case for different stratums on the very same massive (Sonmez and Budakci 2002).

Except for the studies conducted by varnish producing companies to develop their products in Turkey so far on resistance of the varnish stratums against exterior effects, this study dwells on the effects of borax pentahydrate on varnish stratums. With the testing methods implemented on samples used, the study determined the changes in hardness, brilliance and the surfaces sticking values of varnish surfaces implemented on Austrian pine and beech wood surfaces after adding different rates of pentahydrate into double component cellulose brilliant varnish in each time.

The study also informs that the sticking resistance of water-based varnishes prepared for furniture surfaces is lower than the resistance of solvent resolving polyurethane and acrylic varnishes (Budakci 2003).

It is also determined in the study that in polymeric composition varnishes the more that stratum thickness increases, the more its sticking resistance increases (Budakci 1997).

It is also determined that in light-proof paint applications the type of wood does not affect the sticking resistance but the kind of the paint is influential and it is also reported that synthetic paint gave the best result in this frame(Kaygin 1997).

The main reason behind the rapid increase in production and consumption rates of water-dissolvent paint/varnishes and the diversity of their usages stem from the developments and variation in the characteristics and qualities of the stratum creating varnishes. The polyurethane resins constrain an important place in the frame of their usage with the qualities they provide to the product (flexibility, resistance to chemicals and mechanic effects etc.) (Désor and Stephan 1997).

MATERIAL AND METHODS

Wood materials

Beech wood and Austrian pine woods were used while preparing the experimental subject. The subjects were selected randomly from first quality wooden materials, which did not have knots, splits, with no color and smell, chopped vertically according to the annual rings and from strong wood parts in the frame of TS 2470 regulations.

The examples, being exposed to open air humidity, were chopped in 110x110x10 mm sizes and were kept in the climatic refrigerator under 20±2 °C temperature and 50±5 % humidity climate conditions until they reached their dead weight. The average humidity of the randomly selected 10 samples was determined as 9±0,5 %. The samples were reshaped to have the dimensions of 100x100x8 mm and were sandpapered with number 80 and than number 100 abrasives. The dust on the sample surfaces was velured and vacuumed after that. Totally 40 samples, 5 for each wood type and solution concentration, were used during the research.

Pentahydrate

The rate of pentahydrate to be added into the varnish and padding was determined as 0 %, 10 %, 20 % and 30 % of the solid materials rate in the varnishes considering the rate of these materials in varnishes.

The name borax etymologically comes from the "Buraq/baurach" in Arabic and "Burah" in Persian. Borax element, which is at the very top of the 3A group in the Periodical Table and its atomic number is 5. This element has two isotopes with mass numbers of 10 and 11. Its symbol is B and it is the only element in the 111A group which is not metal (Cetin 2002). Borax element is like a white stone at first look and resistance to high temperatures with its strong and hard structure. It does not exist in nature as an independent mater but it is found as salt ingredient in nature. Borax's color while it is in the amorphic dust shape is Brown. However its color is yellowish Brown when it has monoclinic crystal shape. In this shape it is the toughest element after crystal (Bozkir 1995).

Being the 51st most common element on earth Borax can be found in soil, rocks and water generally. The weight range of borax in sea water is 0,5-9,6 ppm; in soil 10-20 ppm and in fresh waters in 0,001-1,5. The high concentrated and economical borax beds exist mostly as borax's compounds tied with oxygen in Turkey and America's dry volcanic areas where hydrothermal activities exist. Physical characteristics of Borax are given in table 2.1. Borax is an element which has many similarities with silicon and carbon; and it's affinity to oxygen is quite high. Being an element, which can be solved in water, which is colorless and spar less, borax first loses heat with when it is exposed to heat and than begins to melt (Kizilirmak 2004).

Borax can be found in two different types as crystal, with 2,33g/cm^3 and as amorph with a density of 2,3g/cm^3 (Kocabas 2002). Borax minerals are classified according to Ca, Na and Mg elements they constitute. The ones with Na root are called borax, Ca rooted ones named as colemanit and Na-Ca rooted type is named as ulexite (Ediz and Ozday 2001).

Even if Borax element can be found in 150 different types in nature with borax oxide economically valuable borax minerals are found with Cad, Nah and MGK elements as hydrate compounds (Zorlu 1978).

Borax minerals can be subcategorized within themselves by dividing them sub compounds as follows:

1. Borates including crystal water,
2. Compound borates (Hydroxyl and/or other salts),
3. Boric acid,
4. Waterless borates,
5. Borosilicate Minerals (Ediz and Ozday 2001).

Most important types of borates which are important in term of commerce and include crystal water and their chemical compositions were shown in Tab. 1.

Tab. 1: Important borax compounds in Turkey and the places they are found (Burdurlu 1994)

Mineral	Formula	B_2O_3 (%)	Place found
Borax	$Na_2B_4O_7\,10H_2O$	36.6	Kirka, Emet, Bigadic, USA
Ulexite	$NaCaB_5O_9\,8H_2O$	43.0	Bigadiç, Kirka, Emet, Argentina
Colemanit	$CA_2B_6O_{11}5H_2O$	50.8	Emet, Bigadic, Kucukler, USA
Boric acid	$Mg_3\,B_7O_{13}Cl$	62.2	Germany
Hydroboracid	$CaMgBO_{11}6H_2O$	50.5	Emet

The importance and usage of borax compounds, which already have a wide usage area in industry, constantly increases day by day. It is used as an indispensable material for more than 400 end products produced today. It is possible to observe borax including materials in any area of modern life. Borax s used in glasses, engine oils and steel rims, vehicle paints in order to increase brightness and decrease scratches. The steel wires in wheels are strengthened with borax also and the fiber optic wires used in computers and walkmans cannot be strong enough without borax element. Borax is also used in fertilizers used in agriculture and in templates and cookie cutters.

The percentages of borax usage according to different areas are as follows: Isolation, fiberglass, and textile industry 41 %; ceramics and its components 13 %; detergent and cleaning industry 12 %, metallurgy industry 8 %, and agriculture industry 7 %, and other areas 19 % (Ediz and Ozday 2001).

Varnish

A double component varnish, which was produced by a particular trademark, was used during the experiments. While giving the examples the ASTM D-3023 regulations were followed, while preparing the varnishes for the application conditions the blend rates of varnishes were adjusted in such rates that will not affect the varnish's performance and the producer's suggestions were followed (ASTM D-3023 1998).

The varnish was penetrated into the woods with the help of a spray gun under room temperature (20 °C). The air pressure of the spray gun was 1-2 bars and aperture of its tip was 1,3 mm. The spray varnish was sprayed to the surface 20cm away from it in a vertical angle and it was moved in parallel directions to help the traces follow each other.

The amount of solid material was determiner of the varnish rate to be applied to the samples (TS 6035 EN ISO 2813 1997). Some of the features of the varnishes used are shown in Tab. 2.

Tab. 2: Features of the varnishes applied to the samples

Type of varnish	Solid material rate (%)	Ph Degree	Amount of Varnish to be Applied (g/m^2)
Filling varnish	40	9.21	75
Brightening varnish	34	8.73	83

After applying the filling varnish onto the samples they were left to dry for 24 hours on a dust free platform under room temperature. After drying the samples were sand papered with number 220 and 320 sand papers equally. The sand paper dust is velured and vacuumed after that it was ascertained once more and last varnish application was made twice.

Experiment method

The samples were kept in the laboratory conditions under 20±2°C heat and 65±3 % relative humidity for three weeks in order to let the varnish stratums applied to the experimental samples. The samples were climated for 16 hours under 23±2°C temperature heat and 50±5 % relative humidity according to ASTM-D3924 regulations.

The toughness of the stratums were measured with the help of a pendulum measuring device with Köning measuring technique and in the frame of ASTM D-4366 regulations. The measuring device was tuned to make 100 undulations in 40 seconds with the help of a caliber glass prior to the measurement process and among the measurement sessions. The measurement process was conducted by counting the undulations of two spindles with 63±3,3 HRC hardness and dimension of 5±0,0005 from 6° to 3°. Principally there is less undulation on mild surfaces and more undulation on tougher surfaces (ASTM D-4366 1984).

Brightness measurements were conducted in the frame of principles defined in TS 4318 EN ISO 2813. According to this the gloss-meter, which measured the brightness with 60° angle, was moved horizontally and vertically to the fibers of the samples (TS 4318 EN ISO 2813 2002). Arithmetical mean of two measurements were considered in the evaluation step. The gloss meter was tuned prior to each measuring session and within the processes with a black glass having 1,567 index of refraction and 100 Lambert for all colors.

During the application multiple rippers with 6 cutting heads with 2mm intervals and 15°-30° wedge angles were used as they are suggested for samples with 50-125 μm width according to TS 6884. In this method, after the stratum was transected according to the determined intervals from one end to the other end until the surface of the sample a film was stuck to the varnish in order to get it out. The equation given below was used while calculating the resistance of the sticking.

$$X = \frac{4F}{\pi . d^2} \quad (1)$$

Here;
X : Sticking resistance (MPa),
F : Splitting force (N),
d : Sample cylinder's radius (mm).

RESULTS AND DISCUSSION

The results of varnishes' surface sticking resistances

Five samples stratums' surfaces were used for each varnish composition and wood type used in the experiments. The varnish sticking measurements were conducted with adhesion measuring device ant the results were given in Tab. 3.

Tab. 3:Varnishes'surface sticking resistance values (MPa)

Surface sticking resistance (MPa)								
Wood type	Beech wood				Austrian pine			
Samples	Pentahydrate rate (%)				Pentahydrate rate (%)			
	0	10	20	30	0	10	20	30
1	0.2420	0.3057	0.3121	0.3503	0.2165	0.2420	0.2579	0.2802
2	0.2292	0.3375	0.3343	0.3439	0.2165	0.2292	0.2484	0.2707
3	0.2388	0.3280	0.3439	0.4012	0.2197	0.2261	0.2611	0.2834
4	0.2420	0.3121	0.3503	0.3662	0.2101	0.2324	0.2643	0.2770
5	0.2324	0.3312	0.3280	0.3757	0.2261	0.2452	0.2484	0.2866
Average	0.2348	0.3225	0.3327	0.3674	0.2177	0.2349	0.2560	0.2795

It was observed that surface sticking resistance values of two different types of woods were close to each other after borax free varnish application. After the borax added varnish application, though, sticking resistance values of two different wood types were different depending on the rate of pentahydrate in the varnish.

According to these results, it was observed that the type of the wood and pentahydrate had great effects on varnish stratum's adhesion value after applying normal and additive containing varnish onto the surface.

Varnishes' toughness measurement results

The measurement of varnish stratums used in the experiment was made with pendulum measuring device and the results are given in Tab. 4.

As the toughness values resulted differently it was observed that the type of the wood and the rate of pentahydrate in varnish are influential in the rate of toughness.

According to these results the type of varnish, type of wood and rate of Pentahydrate are greatly influential in the rate of toughness, which is measured after the wood surface was varnished with pentahydrate varnish. Consequently, using what kind of varnish on what type of wood and the rate of Pentahydrate to be added into varnish are considered to be important factors.

Tab. 4: Pendulum measure toughness values

Toughness measurement values (Pendulum)								
Wood type	Beech wood				Austrian pine			
Samples	Pentahydrate rate (%)				Pentahydrate rate (%)			
	0	10	20	30	0	10	20	30
1	29	29	33	40	22	19	26	28
2	27	30	35	45	21	20	25	31
3	30	31	32	47	22	22	26	29
4	28	29	35	44	24	21	24	27
5	29	30	34	42	20	20	25	31
Average	28.6	29.8	33.8	43.6	21.8	20.4	25.2	29.2

Varnishes' brightness measurement results

5 samples were used for each varnish composition and wood type used in the experiments. Two measurements were conducted for each sample surface horizontally and vertically to the fibers of the wood. Arithmetic means of the measurements were calculated and average surface brightness values were determined and the findings were shown in Table 5.

Tab. 5: Brightness measurement values

Brightness measurement values (60º)								
Wood type	Beech wood				Austrian pine			
Samples	Pentahydrate rate (%)				Pentahydrate rate (%)			
	0	10	20	30	0	10	20	30
1	97.8	64.0	57.5	31.3	91.2	76.2	65.3	32.5
2	98.1	61.7	57.4	34.2	88.8	71.0	60.7	33.2
3	97.5	63.5	61.8	29.8	86.7	72.5	65.4	31.5
4	88.7	62.8	59.2	33.1	90.2	74.1	66.1	34.9
5	96.4	66.8	58.6	32.6	89.6	73.7	66.8	33.8
Average	96.4	63.7	58.9	32.2	89.3	73.5	64.8	33.1

There may be some different results in brightness measurements depending on the direction of the measurement according to the position of the fibers. This diversification of the wood surface may increase or decrease depending on the vertical or horizontal brightness measurement of fibers.

According to the highest brightness results in the varnish compounds was observed in the experimental samples which did not have any pentahydrate included. As the level of pentahydrate added to the varnish increased the surface brightness decreased on the other side. As a result the pentahydrate added to the varnish mats the surface of the varnish and decreases brightness quality of it.

CONCLUSIONS

As a result of the research conducted, it is determined the rate of pentahydrate, which is a kind of borax element, is more influential in the frame of surface sticking resistance, brightness and toughness measurements besides the type of the wood used in samples. The explanations of these effects are given below.

As a result of the researches conducted, it is observed that as the rate of the pentahydrate added into the varnish increased from 0 % to 30 %, the varnish';

Sticking rate increased 56, 47 % in beech wood and 28, 38 % in Austrian pine,

Toughness rate increased 52, 44 % in beech wood and 33, 94 % in Austrian pine,

Brightness rate decreased 66, 59 % in beech wood and 62, 93 % in Austrian pine.

Consequently, the pentahydrate added into the varnish increased toughness and sticking resistance; however, it decreased the brightness rate of varnish on the other side. If high sticking resistance and toughness is demanded while using the varnish pentahydrate should definitely be added. However, it should be considered that this will reduce the rate of brightness as a drawback. In some cases the varnish should be mat while making furniture; for this reason the decrease in brightness turns into an advantage in these cases. Adding pentahydrate into automobile paint in the frame of increasing the sticking and toughness could be subject to another research in the future also.

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Murat Ozalp
Dumlupinar University
Simav Technical Education Faculty
43500 Simav- Kutahya
Turkey
E-mail: mozalp@dpu.edu.tr