Some Coating Properties of Black Alder Wood as a Function of Varnish Type and Application Method

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The objective of this study was to evaluate the adhesion strength and glossiness of black alder wood (*Alnus glutinosa* Gaertn. L.) coated with water-borne and UV varnishes by two application systems. Prior to coating, the samples were prepared by sanding with four combinations of grit size sandpapers, 180 being the final grit. The surface quality of the specimens was measured with a white light profilometer. Any increase in grit size gradually reduced surface roughness, which further influenced the overall coating performance of the samples. UV varnish applied by roller presented higher adhesion strength and gloss as compared to spraying. The specimens varnished with a water-borne finish by spraying exhibited a better adherence to the substrate than those of UV varnished samples by the same method and provided glossiness at 60° geometry in the same range. These results are valuable for the furniture manufacturing industry for generating a better use and efficiency of secondary wood resources in order to achieve value-added products.

Keywords: Black alder; Coating; Adherence; Gloss; Roughness

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INTRODUCTION

The surface treatment of wooden products is intended to protect their surfaces, enhance their overall properties, improve their appearance, and extend the service life of the final products. Finishing is one of the most utilized surfacing methods. Most customers buy furniture products based on their impressions at first glance. Therefore, products should be manufactured with aesthetically appealing surfaces. Surface preparation by processing influences the coating performance and the quality of the final product (Gindl *et al*. 2001).

A manufacturing process preceding the finishing operations usually ends with rotary milling and sanding. The quality of such processed surfaces is influenced by various parameters related to the cutting process, tools, and wood species (Saloni 2005). These processes are expected to leave the surface free of substrate damage. Otherwise, adverse effects such as surface waviness, swelling of compressed fibers, surface checks, and crushings may appear after applying the finish (Stewart and Crist 1982). Usually a sanding process follows the planing to remove machining imperfections, such as knife marks and torn fibers. Recently, Arnold (2010) promoted a new planing technique with notched knives that produced surfaces of high quality. Another previous study investigated the influence of factors such as speed, pressure, and vibration on the quality of sanded surfaces (Pahlitzsch 1970).

High feed speeds generate rough wood surfaces due to the reduced number of traces caused by the abrasive (Carrano *et al.* 2002). The roughness of sanded surfaces also increases with increasing the abrasive grit size (Sinn *et al*. 2004; de Moura and Hernández 2006). A coarse grit size is used for a deep sanding, while finer ones are used for further sanding steps to achieve a homogeneous substrate for subsequent coating application (Ratnasingam and Scholz 2006).

The roughness of wood surfaces influences the wettability properties of the solid surface and subsequently the film performance (Wulf *et al*. 1997). Rough wood surfaces require more finish than smooth surface substrates (Richter *et al.* 1995). Sanded wood surfaces generate a more homogeneous finish than planed surfaces (Collett 1972), but fine sanding obstructs lumens with dust and hinders penetration (de Meijer *et al*. 1998). However, crushed and raised cells produced by sanding contribute to the performance of stain by avoiding over-penetration in the earlywood area and allowing enough finish penetration in the dense latewood area (Richter *et al.*1995). The wetting and sanding of wood causes grain raising, in which fibers and groups of fibers or fiber fragments are involved, twisting and lift as the wood dries down. However, not all wood species face the phenomenon at the same extent; *e.g.*, cottonwood is more prone to grain raising than oak (Koehler 1932). A reduced effect may be achieved by a correct selection of sanding parameters for each species (Evans 2009).

Water-based coatings and UV cured technology are used as alternative eco-technologies for wood coating operations. Waterborne coatings offer many benefits, such as the reduction of solvent emissions, lower material costs, non-toxicity, ease of application, and good gloss retention. Sometimes a poor appearance on wood caused by grain raising may limit their application (Landry *et al*. 2013). Styrene/polyester and acrylic based finishes are mostly used as UV finish layers. They offer considerable advantages over conventional systems, such as low VOC emission, rapid curing, superior wetting, immediate handling, and minimal waste. However, the high costs of raw material and equipment may represent a problem for small companies.

There is a balanced relationship between the substrate, coating material, and its application system when used together to achieve the overall performance of a finished product (Williams and Feist 1994). Earlywood, which is more porous than the latewood zone, behaves differently in terms of adhesion and records higher adhesion strength (de Meijer *et al*. 1998). Wood bleaching mostly influences the quality of coated surface while stained samples reveal the highest adhesion strength (Ozdemir and Hiziroglu 2007). Increasing wood equilibrium moisture content (EMC) causes reduced adhesion strength (Sonmez *et al*. 2009). Weaker adhesion under moist conditions can result from the uptake of moisture in the coating, swelling, and hygroscopic stress (de Meijer *et al.* 1998; Sonmez *et al*. 2011). Surface treatment by impregnation with nano-silver suspensions alters the porous structure of solid wood and the adhesion strength of coatings and paints (de Moura *et al*. 2013; Nejad *et al*. 2013; Taghiary and Samadarpour 2015).

An increase of surface roughness increases the area for mechanical interlocking between coating and wood substrate (Cheng and Sun 2006; Hernandez and Cool 2008; Vitosyte *et al*. 2012). In beech, cellulose varnish has deeper penetration and enhanced adhesion than softwoods, while waterborne coatings generally have lower wet adhesion than solvent borne ones (Sonmez *et al*. 2011; Demirci *et al*. 2013; Ozdemir and Hiziroglu 2015). Birch wood has more cohesive failures than ash when varnished with acrylic-polyurethane (Vitosyte *et al*. 2012).

Gloss is the property of a surface that reflects light and is used to evaluate the quality of a wooden finished product. Gloss quality depends on several factors including wood species, chemical composition, coating system, varnish type, number of layers, and substrate preparation (Zivkovic 2004; Cakicier *et al*. 2011; Bekhta *et al.* 2014).

In Romania, there is a great interest in black alder due to its potential in furniture manufacturing (Salca 2008). There is little or no information on how eco-friendly varnishes adhere to black alder wood surfaces as a function of its surface roughness.

Therefore, the objective of this study was to evaluate the coating performance and surface roughness of two types of eco-varnishes applied to black alder samples.

EXPERIMENTAL

Materials

Black alder (*Alnus glutinosa* (L.) Gaertn.) is a diffuse-porous soft hardwood species. In Romania it is regarded as a secondary soft hardwood species with low commercial value when compared to beech which is the most common wood species in the wood industry. It presents good workability properties and potential for furniture manufacturing. A total of 20 commercially manufactured flat sawn boards supplied by a local sawmill were cut in tangential planed defect-free samples (95 by 300 by 6 mm). The average basic density of the samples was 520 ± 20 kg/m^3.

Machining of the Samples

Samples were conditioned in a climate room at 50 ± 5% relative humidity (RH) and 20 ± 2 °C until they reached 8% equilibrium moisture content. Conditioned specimens were sanded using typical manufacturing conditions and by employing a wide belt sander (Timesavers Inc., Maple Grove, MN, USA) equipped with two working heads. The sanding machine had a 1900 × 1130 mm belt, a 16 m/s sanding speed against the feed direction, a 4.5 bar contact pressure, and a feed speed ranging from 4 to 20 m/min. The equipment was provided with a pneumatic oscillation system along with a self-cleaning setup.

Prior to sanding, all samples were calibrated with 60 grit sandpaper. The five grit sizes of sandpaper (80, 100, 120, 150, and 180) were manufactured from corundum abrasive grains coated with anti-static synthetic resin (SIA Abrasives Industries AG, Frauenfeld, Switzerland).

Four different sanding schedules having two grits for each (180 as final grit size) were used for the experiments. Each program was applied to a group of five specimens. The selection of grit sizes and their sequences followed industrial practice.

The calibration process and each two sanding steps were carried out fiberwise with the same cutting schedule with a feed speed of 12 m/min and a cutting depth of 0.3 mm. A wooden frame was used to keep the sanding direction parallel to the wood grain orientation. Dust was removed using pressurized air after each intermediate sanding step.

Surface roughness measurement of the samples

A MicroProf FRT white light profilometer (Fries Research & Technology GmbH, Bergisch Gladbach, Germany) was used for roughness measurements (Fig. 1a). Two roughness measurements were performed perpendicular to the processing direction per sample in the 2D profile method. Such measuring direction of sanding marks is also perpendicular to the length of anatomical features and contains the most anatomical variation.

A total of 10,000 points were scanned per roughness measurement with a scanning speed of 750µm/s over an evaluation length of 50 mm. The sampling length and measuring resolution were set with respect to the recommendations given in the literature for wood surfaces as 2.5 mm and 5 µm, respectively (Gurau *et al.* 2005). The equipment software automatically applied a Gaussian data filter and the roughness profile was obtained (Fig. 1b).

Two mean parameters recommended for wood surfaces were selected according to ISO 4287 (1998), namely the average roughness (R_a) and the RMS roughness average (R_q). They are equally adequate descriptors of the surface roughness of the wood samples, but do not provide enough information about the surface topography. Therefore, the roughness parameters of the Abott-curve defined by ISO 13565-2 (1996) were also used in order to evaluate the sanded surfaces. The core roughness (R_k) and the fuzzy grain roughness (R_{pk}) were taken into consideration because R_k is the most representative indicator of processing roughness (Gurau *et al.* 2005). However, as long as the anatomical roughness was not removed, the anatomical roughness parameter (R_{vk}) was excluded from the surface quality evaluation.

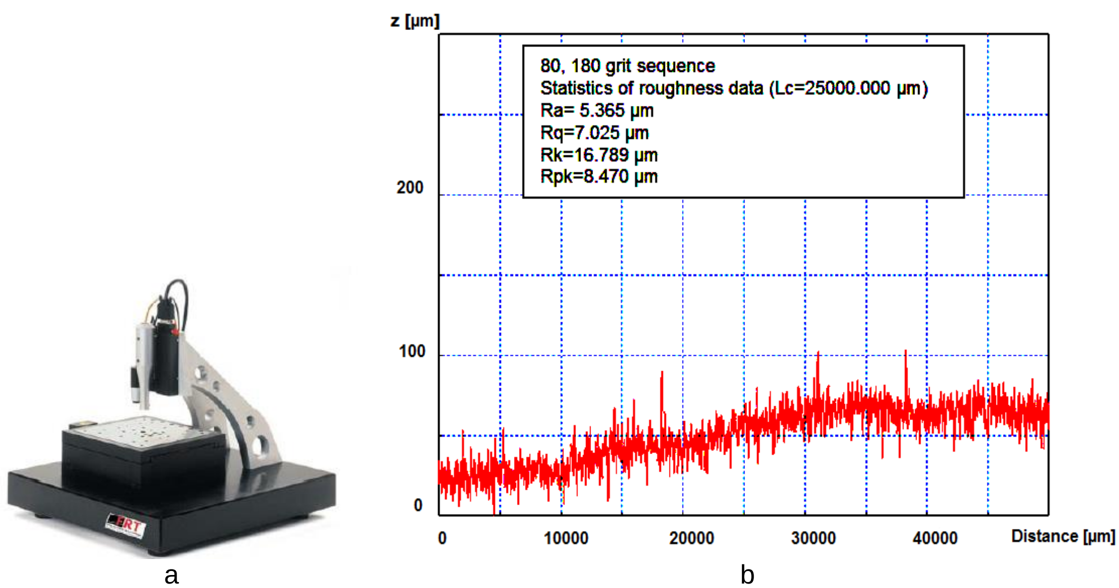


Fig. 1. MicroProf FRT device (a); a typical roughness profile generated by the software (b)

Table 1. Experimental Schedule for Coating

Coating System and Device	Spraying		Roller		Reference Group
	Spray Gun		RK Control Coater		
Varnish Product	A	100% UV Varnish			
	B	Water-borne Varnish			
2 Layers - light 220 grit sanding between layers					
Grit Sequence	Coating System / Group				
	Spraying A	Spraying B	Roller 1A	Roller A	
	Sample 1-5 / Sanding Program				
	1	2	3	4	5
80, 180					
100, 180					
120, 180					
150, 180					

Coating of the Samples

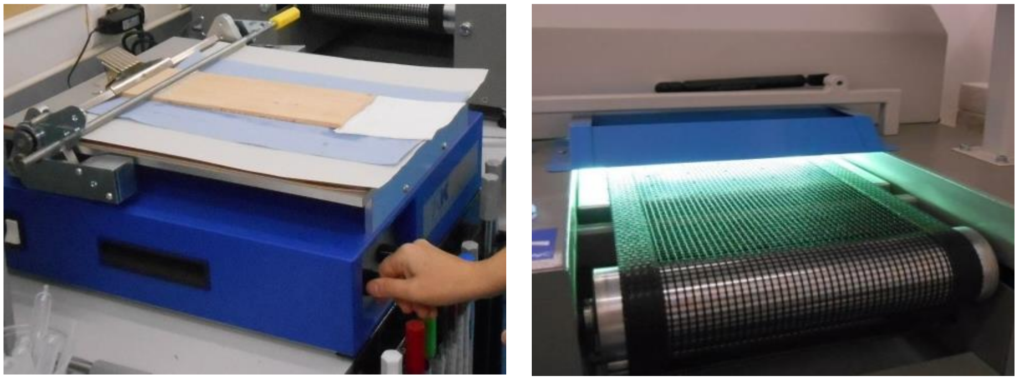
The samples were subjected to finishing under laboratory conditions at Remmers Company in Poland. Two coating methods and varnish products were applied to the samples. The sanded samples were divided into five groups, each with four specimens. One group was kept as control samples. Four coating systems with different application methods and varnish types were used for the samples, as shown in Table 1. The varnishes were supplied by Remmers Company in Poland.

Samples were coated in two sequential steps, namely the initial and final layer, except group 3 to which a single roller-coated layer was applied to further evaluate and compare the coating performance. A light 220 grit sanding was performed between the coating layers to eliminate fiber swells and to achieve surface smoothness. Dust was removed with a soft haired brush.

The UV acrylic top-coat varnish (A) had a VOC EU of 55.2 g/L, a density of 1.229 g/cm^3 (20 °C), a conventional viscosity of 42 s (20 °C) according to DIN 53211 (1974), an organic solvents percentage of 6.5%, and a solid content of 93.5%. The water-borne varnish (B) had a VOC EU of 55.5 g/L, a density of 1.024 g/cm^3 (20 °C), a conventional viscosity of 65 s (20 °C) according to DIN 53211 (1974), an organic solvents percentage of 5.4%, and a solid content of 27.9%. An industrial low-pressure spray gun (0.25 bar) at a spread rate of 120 g/m^2 was used for both varnish products. The samples coated by spraying with water-born varnish were cured at a room temperature of 20 °C and 40% RH for both coating steps, while samples coated with 100% UV varnish were cured in a UV curing unit system.

A roller machine of RK Control Coater type (RK PrintCoat Instruments Ltd., Royston, UK) was used to apply the 100% UV varnish at a feed speed of 4 m/min (Fig. 2a). Two close wound meter bars with wire diameters of 0.3 and 0.08 mm were selected to individually produce 24 µm and 6 µm wet film deposits, respectively.

The UV curing unit of UVC-250x2 type (MIKON UV Ltd., Warsaw, Poland) was used for the curing process of all samples coated by the 100% UV varnish (Fig. 2b). The transporter speed was 20 m/min, and a medium pressure mercury lamp with a high power density of 120W/cm was used.



a b

Fig. 2. RK control coater (a); UV 250x2 curing unit (b)

Adhesion Testing of the Samples

The adhesion of coatings was evaluated by means of a pull-off test according to DIN EN ISO 4624 (2003). A PosiTest-AT type adhesion tester (DeFelsko Corporation, Ogdensburg, NY, USA) was employed for adhesion strength evaluation of the specimens coated with four systems (Fig. 3a).

Five random measurements were taken from each sample by gluing small steel dollies with 20 mm diameters on the film surface with a two component silane-epoxy resin of Jowat 690.00. Tests were performed in ambient conditions (20 °C and 40% RH). After 7 days of curing, incisions were made around the glued dollies to prevent failure damages near the tested area. The adhesion strength was measured using the hand-operated PosiTest device. Delamination was evaluated visually for each specimen.

a b

Fig. 3. PosiTest adhesion tester and dollies glued on the sample (a); PICO GLOSS 503 meter (b)

Surface Gloss of the Samples

Glossiness was measured in accordance with the EN ISO 2813 (2014) standard, using a PICO GLOSS 503 gloss meter (ERICHSEN GmbH, Hemer, Germany) (Fig. 3b). Five gloss measurements were taken perpendicular and parallel to the grain for all control and coated samples. Measurements were conducted at 20°, 60°, and 85°.

Statistical Analysis

An SPSS analysis (IBM SPSS Statistics 23.0, IBM Corporation, Armonk, NY, USA) was conducted in order to point out the influence of individual factors, such as the grit sequence, coating system, and varnish type on the coating performance and the intensity of their interaction with the coating properties.

RESULTS AND DISCUSSION

The roughness of sanded surfaces was evaluated across the grain for all specimens from each sanding process. The average values of surface roughness are given in Table 2. Among all roughness parameters considered in this work, R_k was the most representative for processing, with no errors introduced by wood anatomy (Gurau *et al.* 2005). The highest value of 20.8 µm was found for alder samples sanded with 180 applied after 80 grit size. The largest difference in R_k value of about 16.82% was determined by applying 100 and 180 grit papers, while in case of R_{pk}, only a small difference of 1.94% was noticed between the same programs. The roughness values of the samples decreased gradually for each sanding sequence as the intermediate grit size increased.

Table 2. Roughness Values of Sanded Surfaces

Grit Sequence	R_a (µm)	R_k (µm)	R_{pk} (µm)	R_q (µm)
80, 180	7.1 (2.0)*	20.8 (5.7)	10.3 (2.7)	9.5 (2.6)
100, 180	5.8 (0.9)	17.3 (2.1)	10.1 (3.1)	8.0 (1.5)
120, 180	5.6 (0.8)	16.5 (2.1)	9.6 (2.9)	7.8 (1.3)
150, 180	5.0 (0.2)	15.5 (0.8)	7.4 (0.9)	6.7 (0.30)
* Numbers in parenthesis are standard deviations				

Ozdemir and Hiziroglu (2015) also found similar average R_a value of 4.83 µm in both tangential and radial directions of alder specimens sanded with 180 grit paper. Vitosyte *et al.* (2012) determined an R_a value of 5.14 µm for birch wood sanded with 120 grit paper. De Moura and Hernandez (2006) also obtained similar values for R_a and R_q (4.8 µm and 6.2 µm, respectively) in sugar maple sapwood exposed to the same sequence of 120 and 180 grit papers.

Subsequently, the coating performance of the samples was evaluated through the adhesion strength and surface glossiness as a function of coating system and varnish type correlated to the substrate preparation by sanding (Table 3).

Figure 4 shows that pull-off test failures occurred in both the wood and coating layer. The investigated coatings showed a large adherence to the substrate, exceeding the strength of the adhesive, whereby the measuring-stamps to the surface of the samples were fixed. The destructions mostly had a cohesion character in the substrate. Sometimes delamination between adhesive and coating was observed.

The cohesive failure for alder wood resulted from its distinct wood structure. Its vessels are uniformly spread throughout the wood cross section and the wood structure allows good coating penetration into the wood capillarity system. In low density species, such as alder is, the grain raising is greater and increases the surface roughness, also affecting its wetting characteristics. For any type of coating, a good wetting contributes to a good film performance (Wulf *et al*. 1997).

120,180 grit seq. / spraying A 100,180 grit seq. / spraying B 120,180 grit seq. / roller A

Fig. 4. Delamination of the coated layer as a function of coating procedure and surface preparation

Insignificant differences in adherence were found between samples coated by spraying with 100% UV varnish product (maximum of 1.22 MPa and minimum of 1.14 MPa) (Fig. 5). The highest value of adhesion strength of approximately 1.52 MPa was determined for alder samples sanded with 80 and 180 grit sequences and spray-coated with water-borne varnish. For rough surfaces, the varnish product adhered better to the wood substrate (de Meijer *et al.* 1998). Furthermore, as the surface roughness gradually decreased, the coating lost mechanical interlocking with the substrate, and the adhesion became weaker. Ozdemir and Hiziroglu (2015) found 1.92 MPa as the adhesion strength for alder wood sanded with 180 grit size sandpaper and coated with cellulose varnish.

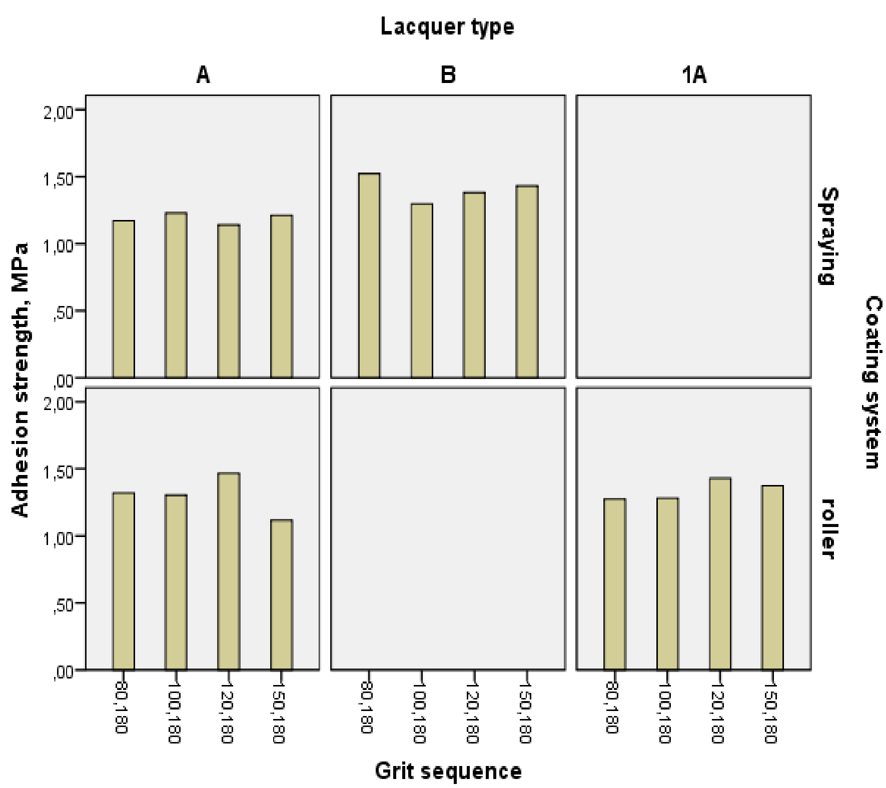


Fig. 5. Variation of adhesion strength as a function of coating procedure and surface preparation

Table 3. Average Values of Adhesion Strength and Gloss as Function of Surface Preparation, Coating System, and Varnish Type

Grit Sequence	Coating System	Varnish Type	Adhesion Strength (MPa)	Gloss 20 II	Gloss 60 II	Gloss 85 II	Gloss 20 #	Gloss 60 #	Gloss 85 #
80, 180	Control	-	-	0.8 (0.4)*	2.5 (0.1)	1.5 (0.5)	0.8 (0.05)	2.0 (0.1)	1.1 (0.2)
	Spraying	A	1.17 (0.09)	5.4 (1.1)	37.8 (5.6)	49.2 (6.4)	4.8 (0.9)	23.7 (3.0)	28.4 (4.2)
		B	1.52 (1.16)	3.6 (0.3)	29.1 (0.9)	46.9 (2.6)	3.2 (1.0)	18.2 (4.9)	23.8 (7.1)
	Roller	A	1.32 (0.16)	31.6 (22.7)	73.6 (14.2)	88.3 (9.2)	37.2 (17.3)	75.4 (12.5)	81.3 (13.0)
		1A	1.27 (0.14)	2.0 (0.9)	14.5 (8.9)	20.4 (16.2)	1.9 (0.5)	10.3 (2.6)	9.8 (4.2)
100, 180	Control	-	-	1.0 (0.1)	3.4 (0.2)	3.8 (0.9)	0.9 (0.1)	2.6 (0.4)	1.4 (0.2)
	Spraying	A	1.22 (0.15)	3.5 (0.4)	27.6 (3.3)	38.0 (5.3)	3.4 (0.7)	18.6 (3.0)	20.5 (2.9)
		B	1.29 (0.11)	5.2 (0.5)	33.8 (1.0)	57.2 (2.3)	4.6 (0.5)	25.5 (2.5)	38.1 (4.7)
	Roller	A	1.30 (0.19)	19.1 (14.4)	61.0 (20.1)	75.0 (20.7)	21.0 (20.4)	52.5 (28.7)	59.5 (29.5)
		1A	1.28 (0.15)	1.2 (0.3)	7.6 (3.0)	8.3 (4.2)	1.3 (0.3)	7.2 (2.0)	6.1 (1.8)
120, 180	Control	-	-	1.0 (0.1)	3.2 (0.6)	3.0 (1.6)	1.0 (0.9)	2.7 (0.4)	1.5 (0.3)
	Spraying	A	1.14 (0.13)	5.1 (0.9)	35.9 (4.5)	46.6 (5.9)	5.1 (0.3)	24.4 (1.0)	27.9 (1.7)
		B	1.38 (0.08)	4.0 (0.5)	30.9 (2.0)	49.6 (3.9)	3.3 (0.3)	18.2 (1.4)	22.9 (2.1)
	Roller	A	1.47 (0.15)	24.5 (20.5)	65.4 (21.4)	81.2 (17.7)	14.7 (10.5)	49.3 (21.5)	53.9 (19.0)
		1A	1.43 (0.22)	1.8 (0.4)	12.6 (3.8)	17.2 (6.7)	1.7 (0.4)	9.9 (2.5)	9.8 (2.8)
150, 180	Control	-	-	1.1 (0.1)	3.1 (0.1)	2.7 (0.7)	1.0 (0.1)	2.4 (0.1)	1.5 (0.2)
	Spraying	A	1.21 (0.11)	5.4 (0.6)	38.6 (2.5)	52.3 (3.0)	5.2 (1.0)	23.8 (3.6)	26.7 (3.6)
		B	1.43 (0.14)	3.7 (0.4)	28.6 (2.8)	49.5 (4.7)	3.5 (0.4)	19.3 (1.7)	25.5 (2.3)
	Roller	A	1.11 (0.13)	21.5 (11.0)	68.1 (15.2)	86.0 (14.2)	16.3 (7.2)	51.6 (17.5)	66.3 (20.1)
		1A	1.37 (0.14)	1.6 (0.6)	12.0 (6.0)	18.8 (11.4)	1.4 (0.5)	7.8 (3.6)	9.6 (4.6)

* Numbers in parenthesis are standard deviations

Roller-coated samples with 100% UV varnish showed similar values for adhesion strength of approximately 1.30 MPa for the first two sanding programs. A maximum of 1.46 MPa was determined for samples sanded with 120 and 180 grit papers. A noticeable difference in adherence of about 23.97% was recorded between this sequence and finer grit sequences such as the 150 and 180 grit sizes. Therefore, finer grit size sequences resulted in lower adhesion strength. Although there is usually more than one layer of varnish applied, the analysis focused on one roller layer of UV product; a similar variation was noticed.

The roller-coated samples with 100% UV varnish presented higher adhesion strength than samples spray-coated with the same product. It appeared that the application system had an important influence on the adhesion strength when considering the 100% UV varnish type applied on alder wood surfaces. The roller system can apply a more uniform and consistent coating layer which significantly influenced the quality of the coated surface. This is due to the roller system accuracy when compared to spray-coating method manually applied. It is fact that a more intense coating led to a better coating adhesion (Arnold 2010).

On the other hand the varnish type also had a particular influence on the adhesion strength, when considering the same application method, in this case by spraying. Results of this study showed that water-borne varnish by spraying generated surfaces that exhibited a better adherence than surfaces coated with UV varnish by the same application system. Water-based finishes cure by coalescing, the droplets of finish move closer together and interlock as the water evaporates (Cakicier *et al*. 2011, Budakci *et al*. 2012). The application of water-based varnish was found to induce greater surface roughness, therefore the area of physical contact increases and this way the coating adheres better to the wood substrate (Vitosyte *et al*. 2012; Landry *et al.* 2013).

Based on alder wood wetting properties, a good film performance was achieved. In previous studies, for species such as pine and beech, it was found that the adhesion strength of the water-borne varnish was lower when compared to solvent-based varnishes (Sonmez *et al*. 2011; Demirci *et al*. 2013) and the varnish types which dry *via* going through a chemical reaction on the wood surface were reported to have high adhesion strength (Demirci *et al*. 2013).

Anatomical structure heavily influences the interaction between coating and substrate. Alder has a semi-porous structure that results in more extensive absorption of the varnish and greater interaction between coating and the substrate (Ozdemir and Hiziroglu 2015). Generally, when surface roughness decreased, there was no interdependence with the coating system and the varnish product. Similar behavior was mentioned for coated birch wood having the same vessel distribution (Vitosyte *et al.* 2012).

As expected, finer grit sizes enhanced the surface glossiness. This trend was noticed for both coating systems when UV varnish was used. The gloss of a varnished layer was determined in a previous study to be dependent on the smoothness of the surface as well as on its ability to reflect light (Demirci *et al*. 2013). Such brightness can be provided on a material surface whose pores are completely filled (Pelit *et al.* 2015). Therefore, by applying a roller-controlled coating thickness, the glossiness effect of such coated surfaces was found to be higher than the gloss effect resulted for spray-coated surfaces with same UV varnish product. Moreover, coatings with higher resistance *e.g.* to mechanical factors are expected to be obtained by employing a roller UV system.

The glossiness for 60° geometry was analyzed for all samples along and across the grain (Fig. 6). With spray coating, both varnishes produced almost similar glossiness at 60° geometry. For UV products, the maximum gloss at 60° II and # were 38.6 and 23.8, respectively. For water-based varnishes, the maximum gloss at 60° II and # were 33.8 and 25.5, respectively. Values over 61 for gloss at 60° II and 49.3 for gloss at 60° # were found in the case of samples that were roller-coated with UV varnish.

It is known that structural differences of the varnishes and the application methods can influence the glossiness effect (Pelit *et al*.2015). Water-borne varnishes were reported to affect adversely the smoothness of the surface, reducing the gloss of the layer (Sonmez *et al*. 2011). Similar findings were reported in terms of hardness, gloss and adherence by Demirci *et al.* (2013). In this study, both varnishes applied by spraying, were almost in the same range of glossiness, but some small differences were noticed. In case of UV varnish, the coating structure is more cured due to the influence of the UV energy when compared to water-based varnish type, which explains such differences in gloss values.

The SPSS analysis revealed that both factors, coating system and varnish type, had a significant influence on coating performance (Sig. ≤ 0.05). The partial eta squared coefficient ($\eta^2 \geq 0.50$) showed a higher intensity for the interaction of varnish type and coating system with gloss properties at 60° geometry.

This study presented some finishing properties of alder wood as function of varnish type and application method. Findings of this work are useful in furniture manufacturing sector to achieve value-added products. For further studies, water-based and UV curing products applied on the surfaces of black alder specimens should be evaluated in terms of artificial aging to simulate indoor exposure.

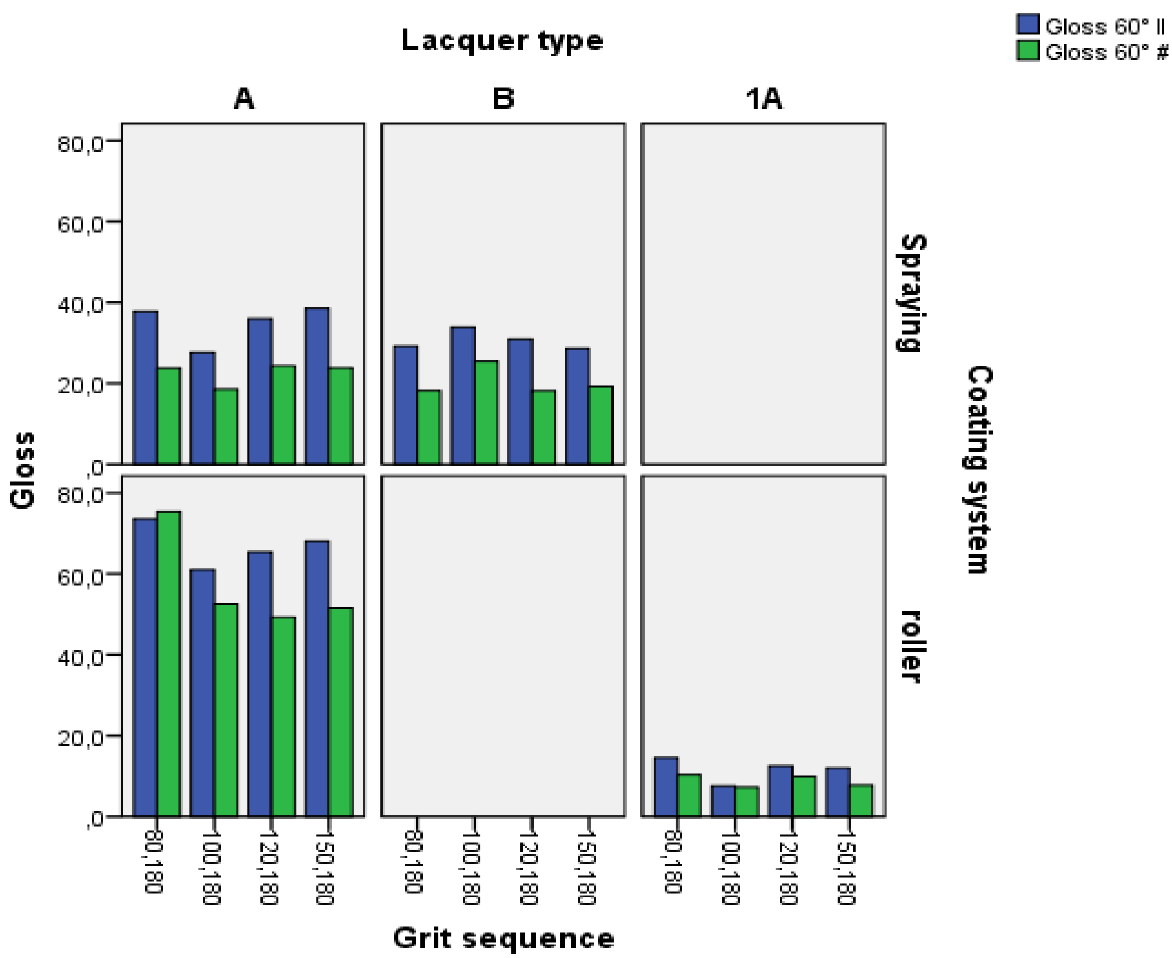


Fig. 6. Variation of surface gloss at 60° as a function of coating procedure and surface preparation

CONCLUSIONS

1. There is a balanced relationship between substrate preparation, coating material, and its application system. Any increase in grit size for the sanding step gradually reduced the surface roughness, which further influenced the overall coating performance. A combination of 120 and 180 grit papers was the optimal surface preparation.
2. In terms of adherence, roller-coated samples with 100% UV varnish presented higher adhesion strength than samples spray-coated with the same product. Water-borne varnish by spraying generated surfaces that exhibited a better adherence than surfaces coated with UV varnish by the same application system.
3. Generally, it was noticed that finer grit sizes enhanced surface glossiness. The roller system of 100% UV varnish gave surfaces with higher glossiness than samples coated by spraying of the same product. Both varnishes used in this study provided by spraying glossiness at 60° geometry almost in the same range.
4. These results might be valuable for the furniture manufacturing industry to generate a better use and efficiency of secondary wood resource in order to achieve value-added products.

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