Effect of Priming of Wood Surface on the Adhesion Strength of Coating in Furniture and Other Wooden Products

Mohammad Ghofrani, [a1] Hossein Baghery,[a2] and Saeed khojasteh Khosro [a2,]*

In this study, the effect of priming on the adhesion strength of coating in ash (Fraxinus excelsior L.), sycamore (Platanus orientalis), pine (Pinus halepensis mill), and walnut (Juglans regia) wood species was investigated. For this means, specimens were prepared at the size of 200×100 ×12 mm, and an 8% moisture content (in the radial direction). After sanding the specimen's surface with sandpaper, they were separately covered with shapan, oil, and bars primers. After priming, an acid catalyzed clear coat was applied to the specimen surfaces. To analyze the effect of priming on the adhesion strength, the primed specimens were compared with control specimens. The obtained results from this study indicated that coating the surfaces of wood specimens with oil and bars primers does not have a negative impact over the adhesion strength, but the shapan primer significantly reduced the adhesion strength of coating. The highest adhesion strength on the wood surface was from the walnut species without priming, and coated with bars and oil primers.

Keywords: Adhesion strength, Priming, Wood species, Acid catalyzed, Furniture, Radial direction

Contact information: a: Wood Science and Technology Department, Faculty of Civil Engineering, Shahid Rajaee Teacher Training University, 16785-163, Tehran, Iran.
**Corresponding author: s_khojasteh@ymail.com*

INTRODUCTION

One of the important stages in painting wood is the infrastructure of the wood's surface, and the operation done before applying the final coating on the wood surface. The better the preparations are done and the factors affecting the wood coating (moisture content of wood, density, hardness, surface quality, etc.) are controlled, eventually the appearance (gloss, transparency, *etc*.) and physical (surface adhesion and wetting, *etc*.) properties of the final coating will be improved (Sonmaz *et al*. 2009, 2011; Manavi *et al.* 2012; Taylor *et al.* 1999; Cole and Hernandez 2011). Faochio *et al.* (2006) also stated that when producing wooden furniture and products, the preparation and polishing the surface before coating are of the most importance for the technical, economic, and beauty analysis of the wooden products.

Fernando (2006) evaluated varnish coating performance for three surfacing methods on sugar maple wood. The results indicated that sanding created the highest roughness and the best wetting in the wood's surface, comparing to the cross-grain helical-knife planning, and oblique-knife pressure-bar cutting methods. The lowest roughness was related to indirect cross-grain helical-knife planning, but this method created some lint. Generally in the sanding method, by increasing the grit size, the

roughness and surface wetting decreased. In a previous study, Cole and Hernandez (2011) stated that the sanding stage and the feeding rate when polishing the black spruce wood surface were considered some of the factors affecting the coating's adhesion to the wooden surface. Also Ghofrani and Khojasteh Khosro (2014) investigated the effects of sanding of wood surface before applying the coating on the adhesion strength. The results showed that the surface preparation process preceding wood coating with sandpaper had significant effect on the adhesion strength of coating on the wood surface. With decreasing grit size of sandpaper, the useful life of wooden products will be improved by increasing adhesion strength of coatings.

The study by Sonmaz *et al*. (2009) in analyzing the effect of wood's moisture content on the adhesion of coatings indicated that with the increased amount of moisture, the adhesion of the final coating decreases, and the oak species had more adhesion comparing to the pine and beech tree. Furthermore, the polyurethane coating showed more adhesion comparing to the nitrocellulose coatings. Manavi *et al*. (2012) studied the effect of moisture content on the adhesion strength of commonly used coatings in Iran such as sealer - clear and sealer - acid catalyzed. They stated that the maximum adhesion strength at an 8% moisture is achieved when using a sealer with an acid-catalyzed coating, for which its adhesion strength increases by decreasing the moisture.

One of the operations that is done before the final coating of the furniture and wooden art, which is of the most importance, is priming the surface of the products. Primers are comprised of solid decorative substances that are soluble in various solvents, or which are prepared in different shapes and sizes in their respective solvents, in the form of a solution or suspension, and are used to prepare the work surface (changing the wooden background to the ideal color) before the final coating (Roshan Baksh *et al*. 2012). In view of the importance and common use of priming the wooden surface to create various colors on the woods surface, and to also unify the color (integration of the color) when wood with various colors are used to create wooden products in the furniture industry and handicrafts, the goal of the present work was to evaluate the effects from used primers in the wood coloring industry with 3 different solvents (water, thinner, and gasoline), on the adhesion of common coatings in the painting of wooden products. According to the aim above, the results of the inducted study could be used by the owners of furniture industry and art products in applying the appropriate primer, before coating the wooden furniture or products.

EXPERIMENTAL

Materials

The wood species used in this study included: ash (*Fraxinus excelsior L.*), sycamore (*Platanus orientalis*), pine *(Pinus halepensis mill*), and walnut (*Juglans regia*), which their average density was respectively at 0.60, 0.63, 0.40, and 0.68 g/cm^3. All samples prepared from sapwood in radial surface. The main factor in choosing these four species, was their vast use in the industries related to furniture, wooden doors and windows, and handicrafts in Iran. The chosen specimens had normal growth conditions, no knots, reaction wood, decay, and fungal diseases.

The sealer and acid catalyzed clear coatings produced in Iran were used for the coating of wooden specimens in this study. The characteristics of the used clear coats are mentioned in table 1.

Table 1. Characteristics of the Used Clear Coats

Type of coating	pH	Density (g/cm^3)	Viscosity (CP)	solid content (%wt)	Solvent amount (relative to the coating weight)
Sealer	2.9	0.95	140	26.58	2 times
Acid catalyzed	3.8	0.96	130	37.68	0.5 times

The primers used in this study for the means of coating the wood specimens, included the bars, shapan, and oil primers. The characteristics of the used primers are also set forth in Table 2.

Table 2 .Characteristics of the Used Primers in the Study

Primer	Solvent	Main ingredient	Solvent amount (relative to the primer weight)
Bars	Water	Walnut bark	7 times
Shapan	Gasoline	Refined tar	5 times
Oil	Oil thinner	Oil cover	4 times

Methods

The prepared ash, sycamore, pine, and walnut species were exactly cut into purely radial boards, which after drying up in the furnace to 8% moisture content, were turned into pieces with a size of 200×100×12 mm. The surface on the prepared specimens were sanded by hand, using a variety of rough to soft sandpaper in the direction of the wood's grain with 80-120-180 grit sizes. To prime the prepared specimens, the surface of all specimens except the control, were coated in 3 separate functions with the bars, shapan, and oil primers, which were applied via a priming canvas. The surface of the wood specimens was first coated with sealer, which is used to fill the wood's pores. The sealer coated specimens were placed in the lab for 24 hours, for the aim of drying and better stabilizing the coating. The point that must be mentioned about the specimens coated with the oil primer, is that to prevent the sealer coating from burning up after applying on this coat, the specimens must be coated with sealer immediately after applying the oil primer (before the oil primer dries). In the final stage, the wood specimens are coated with a final layer of acid catalyzed at the amount of 120 ± 10 g/m^2, using an airbrush. The amount of usage of the dryer in the acid catalyzed coating to dry faster was 10% relative to its weight. During the usage and drying of the specimens, the temperature conditions were at 20 ± 2 °C, and the relative humidity at 65 ± 5% (Boxall *et al.* 1984).

Adhesion Strength

To measure the adhesion strength, cylindrical pieces (Dolly) made from aluminum at a diameter of 20 mm were glued to the specimens, using the UHU duo-part epoxy glue manufactured in Germany. The ratio of used glue was 150 ± 10 g/m^2, according to the ASTM D-4541 standards. Specimens were placed in the lab for 24 hours (20 °C) to dry. The adhesion strength of the specimens was measured with the PosiTest

AT automatic adhesion test device, at a tension speed of 0.3 MPa/s. The method used to measure the adhesion strength, was the Pull Off test according to the ASTM D-4541 standards. To be assured from the result's accuracy, the replication for each specimen was determined at 5 times.

Statistical analysis

Statistical analysis was conducted using SPSS software program version 22 (2013). Two-way analysis of variance (ANOVA) was performed on the data to determine significant differences at the 95% level of confidence. Duncan Test was used to determine the significant difference between among the groups.

RESULTS AND DISCUSSION

The results indicated that in the single effect of the wood species, the highest adhesion strength was found in the walnut species, and lowest in the pine species (Fig. 1). In the analysis of the effect of priming the wood surface on the adhesion strength of coating, it was determined that the highest adhesion strength was obtained from the control specimens and the specimens primed with oil and bars. No significant difference was observed between these two conditions. On the other hand, priming the surface of the specimens with shapan significantly decreased the adhesion strength. The lowest adhesion strength was observed in the specimens primed with this ingredient (Fig. 2).

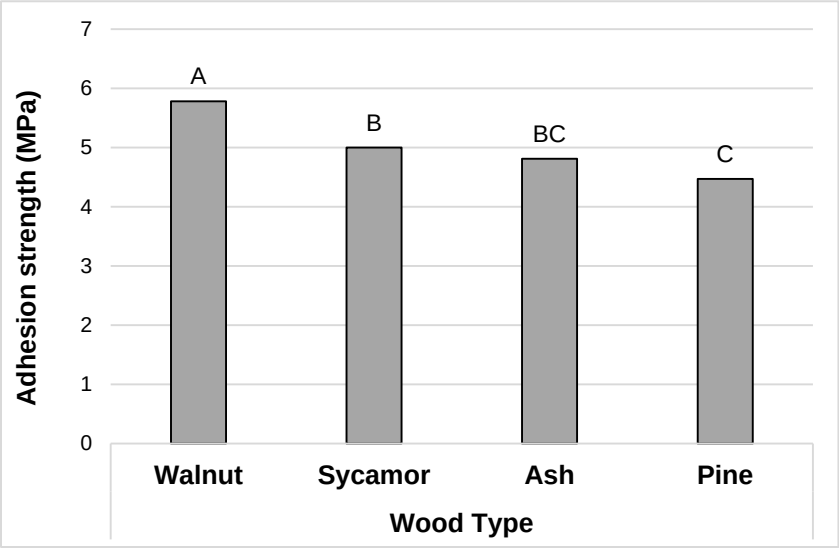

Fig. 1. Single comparison results for wood type

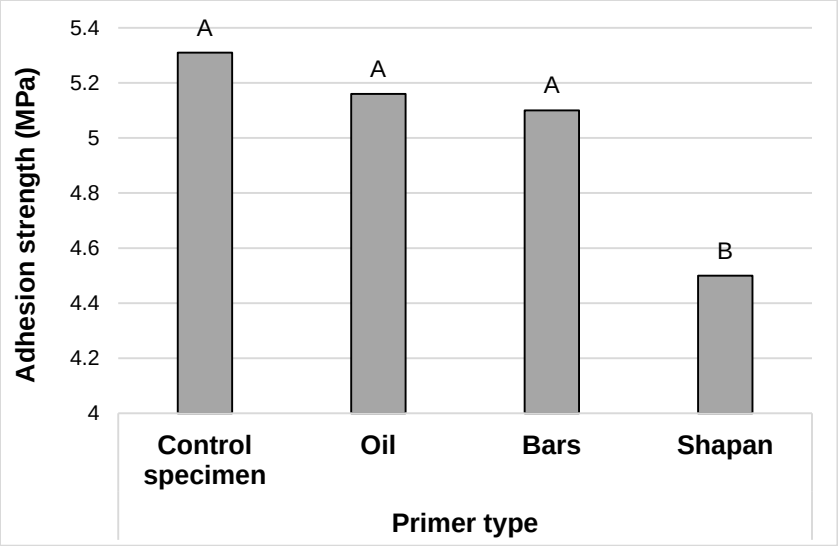

Fig. 2. Single comparison results for wood type

The interaction from the wood species and the priming indicated that the highest adhesion strength was seen in the control specimens, and also the walnut specimens primed with bars and oil. On the other hand, the results showed that the lowest adhesion strength was in the pine specimens primed with shapan (Fig. 3).

In the analysis of the results related to the wood species effect on the adhesion strength of the coating to the wood's surface, the maximum amount was observed in the walnut species, which was higher than the ash, sycamore, and pine species. One of the important issues in wood is that the higher the wood's porosity, the weaker it gets, also the damage that the wood's surface experiences during the preparation process, increases (Latibati 2007). The reduction in the wood's surface quality could affect the adhesion strength of the coating, and reduce it as well. Also the results confirm this issue, and the highest adhesion strength was seen in the walnut species, because of its highest density. Kaygin and Akgun (2008) stated in the analysis of the wood species effects, that various wood species have different adhesion strengths, because of their different anatomic structure such as density, hardness, cellular structure, chemical compounds, and extractives.

The study inducted on the effect of priming the wood's surface indicated the lack of a negative effect from the oil and bars primers on the adhesion strength. On the other hand, the results indicated a negative impact from the shapan primer on the coating's adhesion to the wood's surface, and the lowest adhesion strength was observed in this primer. The negative impact from the shapan primer could be attributed to its primary structure, which is from refined tar. Priming with shapan creates a layer on the wood, which reduces its surface adsorption and permeability (Roshan Baksh *et al*. 2012), and as a result prevents the proper penetration of the coating into the wood and creating an appropriate connection between the coating and the cell wall. This effect is not seen in the oil and bars primers and these materials properly penetrate the wood's surface. So, coating the surface of wood with such primers does not cause a disorder in the

penetration of the coating inside the surface (Roshan Baksh *et al*. 2012), which is because of the structure of these materials (Table 1).

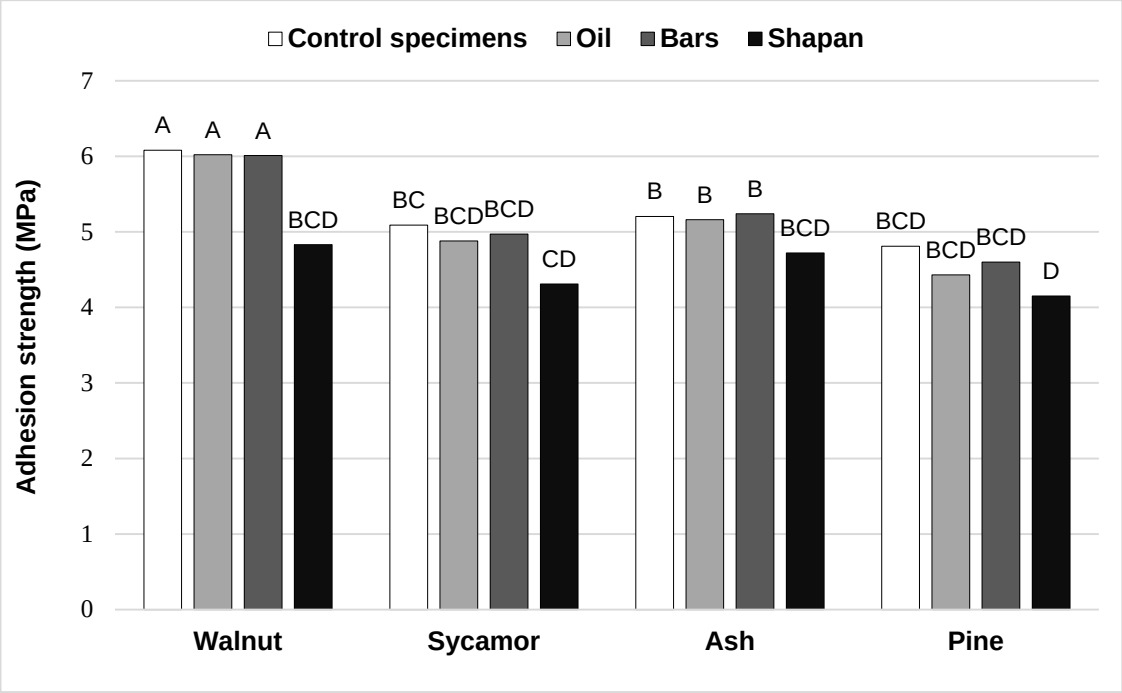

Fig. 3. Total comparison results for wood type and primer interaction

CONCLUSIONS

1. The results from the conducted study indicated that the oil and bars primers are the best primers to change the color of the wood to the ideal color in wooden furniture, which is because they have no negative impact on the coating's adhesion strength on the wooden surface.
2. Results showed that the shapan primer, which is used as a common primer in the wooden furniture industry and art to create the ideal color on the wood's surface, significantly reduces the coating's adhesion to the wood's surface; therefore is not recommended for this purpose.
3. To use the appropriate primer while coating the wooden surface, in addition to the beauty of the products, the negative impact from the primer must be prevented. The selection of a suitable primer is important to increase the durability and performance of the product, by increasing the adhesion strength during operation and usage period of that production.

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