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Improving Physical and Surface Characteristics of Oriental beech Using PEG-400, Vaseline, and Epoxy Coatings

Poboljšanje fizičkih i površinskih svojstava kavkaske bukovine primjenom PEG-400, vazelina i epoksidnih premaza

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ABSTRACT • *Wood is widely used in construction and furniture industries; however, its physical and surface properties are often affected by weathering. This study evaluates the physical and surface properties of Oriental beech wood treated with some chemicals and protective coatings to improve durability. Specimens were impregnated with a 3 % aqueous solution of polyethylene glycole-400 (PEG-400) and vaseline (V), followed by an epoxy resin (EPR) coating. Physical tests such as oven-dry density, air-dry density and water absorption tests were performed. Also, some surface tests such as color and adhesion strength tests were conducted after three months of natural weathering in Muğla, Turkey. Results demonstrated that the combination of vaseline treatment and epoxy resin coating yielded the highest color stability. Chemical impregnation before epoxy coating caused significant decrease in adhesion strength of wood before weathering. While weathering caused a general decline in adhesion strength, pre-impregnation with chemicals before epoxy coating significantly reduced this decrease. Furthermore, impregnated and coated specimens exhibited higher oven-dry and air-dry densities alongside reduced water absorption compared to untreated control group, highlighting the effectiveness of these treatments.*

KEYWORDS: *impregnation; coating; color; adhesion test; oven-dry and air-dry densities; weathering*

SAŽETAK • *Drvo ima široku primjenu u graditeljstvu i industriji namještaja, no na njegova fizička i površinska svojstva često utječu okolišni uvjeti. U ovoj se studiji ocjenjuju fizička i površinska svojstva kavkaske bukovine obrađene određenim kemikalijama i zaštitnim premazima radi poboljšanja njegove trajnosti. Uzorci su impregnirani 3-postotnom vodenom otopinom polietilen glikola-400 (PEG-400) i vazelinom (V), nakon čega su premazani epoksidnim premazom (EPR). Provedena su ispitivanja fizičkih svojstava kao što su gustoća apsolutno suhog*

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drva, gustoća drva sušenog na zraku i sposobnost upijanja vode. Također, ispitane su boja i adhezivna čvrstoća uzoraka nakon tri mjeseca izlaganja prirodnim vremenskim utjecajima u Muğli, u Turskoj. Rezultati su pokazali da je kombinacijom zaštite vazelinom i epoksidnim premazom postignuta najveća stabilnost boje. Kemijska impregnacija prije nanošenja epoksidnog premaza rezultirala je znatnim smanjenjem adhezivne čvrstoće prije izlaganja vremenskim utjecajima. Izlaganje vremenskim utjecajima prouzročilo je opći pad adhezivne čvrstoće, ali znatno manji u uzoraka s kemijskom impregnacijom. Nadalje, impregnirani i premazani uzorci imali su veću gustoću drva u apsolutno suhom stanju i gustoću drva sušenog na zraku, uz smanjeno upijanje vode u usporedbi s nezaštićenim kontrolnim uzorcima, čime je potvrđena učinkovitost navedenih tretmana.

KLJUČNE RIJEČI: *impregnacija; premaz; boja; ispitivanje adhezije; gustoća drva u apsolutno suhom stanju; gustoća drva sušenog na zraku; izlaganje vremenskim utjecajima*

1 INTRODUCTION
1. UVOD

Wood has been a fundamental raw material throughout human history, valued for its versatility and utility. However, dwindling forest resources have necessitated more efficient processing techniques and strategies to extend its service life. Despite its lower density compared to materials like iron and steel, wood offers several advantages, including ease of transport, resilience under diverse loadings, low energy consumption during processing, and excellent workability (Kurtoğlu, 2000).

Surface treatments such as staining and varnishing can enhance its aesthetic appeal, and wood often becomes more visually striking with age. Epoxy-based coatings have emerged as a viable alternative for enhancing the durability of wood. Unlike biocide-based formulations, epoxy coatings form a protective physical barrier that significantly improves the wood resistance against moisture, UV radiation, and mechanical wear (Gonçalves *et al*., 2022). The hydrophobic nature of epoxy resins reduces water absorption, preventing dimensional instability and fungal decay without the need for toxic chemicals (Wang *et al*., 2021). Moreover, epoxy formulations exhibit strong adhesion properties, which enhance their long-term performance, making them suitable for both interior and exterior applications in harsh environmental conditions (Ferdosian *et al*., 2017)

Recent studies have demonstrated that epoxy coatings not only improve the aesthetic and structural properties of wood but also provide superior performance of coated wood. For instance, epoxy-modified wood has been found to exhibit enhanced mechanical strength and surface hardness, making it more resistant to physical impacts and weathering effects (Sienkiewicz *et al*., 2022). Additionally, researchers have explored hybrid epoxy formulations incorporating nanomaterials, such as silica and graphene, to further improve the thermal stability and barrier properties of epoxy-treated wood (Saba *et al*., 2016). Özgenç *et al.* (2012) highlighted the application of surface treatments such as paints, varnishes, polishes, and water repellents to safeguard wood material surfaces from UV radiation and other environmental factors. Similarly, coatings have been shown to protect fiberboard, particleboard, and solid wood from UV exposure (Burdurlu and Özgenç, 2009). However, top-surface treatments like painting and varnishing often provide only superficial protection. It is worth noting that the protective effect of surface treatments (film layer integrity) largely depends on geographical location and exposure, and in extreme cases this period can be reduced to up to 2 years (Sönmez *et al*., 2002). To ensure long-term durability, it is essential to impregnate wooden materials with water-repellent, biotic, and abiotic chemical substances before varnishing and painting (Örs *et al.*, 2002).

Epoxy resins have recently gained prominence as coating materials in the wood preservation industry. These thermosetting plastics, which can transform from liquid to solid through curing agents, are widely used in applications such as insulation, coating, lamination, and marine construction, as well as in space and aviation industries (Saba *et al*., 2016). Epoxy resins offer superior adhesion, mechanical properties, and dimensional stability compared to other thermosets and thermoplastics (Mishra and Biswas, 2013; Jawaid and Abdul Khalil, 2011).

In this study, Oriental beech wood was impregnated with PEG-400, a dimensional stabilizer, and vaseline, a water repellent. The impregnated wood was subsequently coated with epoxy resin to enhance its physical and surface properties. The primary objective of this research is to improve the physical characteristics of Oriental beech wood, such as water absorption, oven dry, air-dry densities, and enhance surface qualities like color stability and strength of film on wood surface exposure to weathering conditions.

2 MATERIALS AND METHODS
2. MATERIJALI I METODE

2.1 Preparation of specimens
2.1. Priprema uzoraka

Wood specimens were prepared from the sapwood of a 40 cm diameter Oriental beech tree (*Fagus orientalis*), sourced from 150 cm above ground level.

During the preparation process, wood pieces with smooth fibers, free of knots, cracks, and insect or fungal damage, were carefully selected. The planks were sawn to a thickness of 50 mm. Specimens were air-dried and prepared for the following tests:

Color and adhesion strength tests: Specimens with dimensions of 10 mm × 100 mm × 150 mm (radial × tangential × longitudinal directions).

Oven-dry density and air-dry density tests: Specimens with dimensions of 20 mm × 20 mm × 20 mm (radial× tangential × longitudinal directions).

Water absorption (WA) tests: Specimens with dimensions of 20 mm × 20 mm × 20 mm (radial × tangential × longitudinal directions).

2.2 Impregnation procedure
2.2. Postupak impregnacije

PEG-400 was used as a dimensional stabilizer, while vaseline served as a water repellent chemical. Specimens were impregnated using a 3 % aqueous solution of PEG-400 and vaseline, respectively, following the ASTM D1413-07 (2007) standard. After 30 minutes of vacuum impregnation at 600 mm/Hg, the specimens were submerged in the solutions for 60 minutes at air pressure. The impregnation process was carried out at the oven-dry and air-dry densities for each test specimens.

Since vaseline is solid at room temperature, it was heated to 70 °C before the impregnation process. The retention quantity was calculated using Eq. 1:

$$\text{Retention} = \frac{G \cdot C}{V} \cdot 10^3 \ (\text{kg/m}^3) \tag{1}$$

Where:
$G = T_2 - T_1$
T_2 – Specimen mass following impregnation (g)
T_1 – Specimen oven dry mass before impregnation (g)
V – Specimen volume in cubic centimeters
C – Solution concentration (%)

2.3 Coating procedure
2.3. Postupak premazivanja

Following the impregnation process with PEG-400 and vaseline, the epoxy coating procedure was carried out. The epoxy resin used in this study, Sikafloor®-156, was sourced from Sika, a commercial supplier based in Istanbul. According to the manufacturer's instructions, the epoxy composition was prepared manually by mixing epoxy resin and hardener in a 3:1 ratio (epoxy: hardener by weight).

After coating, the specimens were conditioned under controlled environmental conditions of 20 °C and 65 % relative humidity for two weeks to ensure complete curing. This conditioning process was crucial for stabilizing the specimens before conducting the subsequent tests for color stability, adhesion strength, water absorption, oven-dry density, and air-dry density.

2.4 Color test
2.4. Ispitivanje boje

The CIEL$*a*b*$ color test method was used to determine the specimen colors. In this figure, the $a*$ and $b*$ axes represent chromaticity coordinates, and the $L*$ axis represents lightness. Moreover, red and green are represented by the symbols $+a*$ and $-a*$. The constant $+b*$ represents yellow, and the constant $-b*$ represents blue. Zhang (2003) states that the $L*$ value has a range of 0 (black) to 100. In this test, the ASTM D1536-58 T (1964) standard was followed to calculate the color difference ($\Delta E*$) using Eqs. 2-5.

$$\Delta a^* = a_f^* - a_i^* \tag{2}$$

$$\Delta b^* = b_f^* - b_i^* \tag{3}$$

$$\Delta L^* = L_f^* - L_i^* \tag{4}$$

$$(\Delta E^*) = [(\Delta a^*)^2 + (\Delta b^*)^2 + (\Delta L^*)^2]^{1/2} \tag{5}$$

The variables $\Delta a*$, $\Delta b*$, and $\Delta L*$ reflect the differences between the first and last intervals, respectively.

2.5 Adhesion test
2.5. Ispitivanje adhezije

TS EN ISO 4624 (2016) and ASTM D-4541 (2017) were used to assess the specimens adhesion strengths. Test dollies with a 20 mm diameter were glued on specimens at room temperature (20 °C ± 2 °C) in order to measure the adhesion strength. After that, the specimens were allowed to dry for a full day. The adhesion tester has a feed rate of 5 mm/minute. The adhesion strength (X) was calculated using equation 6.

$$X = \frac{4 \cdot F}{\pi \cdot d^2} \left(\frac{N}{mm^2}\right) \tag{6}$$

Where:
F – Force at break (Newton)
d – Diameter of test cylinder (mm).

2.6 Oven-dry and air-dry densities test
2.6. Ispitivanje gustoće drva u apsolutno suhom stanju i gustoće drva sušenoga na zraku

Following the TS 2472 (1976) standard, the oven-dry density (δ) measurements were carried out. In order to attain a standard mass, wood specimens were dehydrated at 103 °C ± 2 °C. The specimens were cooled before their dimensions, volumes, and masses were measured with an analytical scale that had a sensitivity of 0.01 g, stereometric measurement, and precision calliper measurement with 0.01 mm resolution.

Then, using Eq. 7,

$$\delta = = \frac{M_0}{V_0} \ (\text{g/cm}^3) \tag{7}$$

Where:
M_0 – specimen's oven-dry mass (g)
V_0 – specimen's oven-dry volume (cm^3)

The air-dry density (δ) of the test specimens was determined using the TS 2472 (1976) standard. The specimens were housed in a compartment with a temperature of 20 °C ± 2 °C Band a relative humidity of 65 % ± 3 % until their mass stabilized. Following a 0.01 g analytical scale weigh-in, the specimens dimensions, air-dry density, and volumes were calculated using Eq. 8 and the stereometric method.

$$\delta = \frac{M_{12}}{V_{12}} \ (\text{g/cm}^3) \qquad (8)$$

Where:
M_{12} – specimen oven-dry mass (g).
V_{12} – specimen oven-dry volume (cm^3).

2.7 Water absorption test
2.7. Ispitivanje upijanja vode

The specimens were kept for 2, 6, 14, 30, 62, 94, and 126 hours in distilled water in a room environment. Specimens were taken out of the water after each soaking interval, dried on paper, and weighed right away. Consequently, equation (9), which estimates the water absorption (WA) for each specimen, was applied.

$$WA = \frac{M_f - M_{0i}}{M_{0i}} \cdot 100 \qquad (9)$$

Where:
M_{0i} – specimen oven-dry mass following impregnation (g)
WA – water absorption percentage (%)
M_f – specimen mass following water absorption (g)

2.8 Weathering test
2.8. Izlaganje vremenskim utjecajima

From January 5, 2024, until April 5, 2024, the wood of Oriental beech was subjected to weathering for three months. In accordance with ASTM D 358-55 (1970), the wood panels were ready for weathering. In the South Aegean Region, close to the Muğla Regional Meteorological Observation Station, a test site has been set up for practical assessments. Table 1 provides the Muğla meteorological statistics.

2.9 Statistical evaluation
2.9. Statistička obrada podataka

The Duncan's test and variance analysis were assessed by the SPSS computer once the test results were obtained, and they were covered with a 95 % confidence level. The homogeneity groups (HG) were the subject of statistical analyses, with different letters indicating statistical significance.

3 RESULTS AND DISCUSSION
3. REZULTATI I RASPRAVA

3.1 Color test
3.1. Ispitivanje boje

The color and total color change values of specimens impregnated with polyethylene glycole-400 (PEG-400) and vaseline (V) and coated with epoxy resin (EPR) are given in Table 2.

The color of wood is crucial in terms of aesthetic and hedonic notions for consumers. Depending on culture, location, and financial level, wood items may have a higher market value just because of their hue (Korkut *et al.,* 2013). Before weathering, the L^* values of all impregnated and coated specimens were lower than the control group. The specimens treated with PEG-400+EPR exhibited the lowest L^* values. Our findings revealed that all impregnated and coated specimens had higher a* values than the control group. Af-

Table 1 Muğla meteorological statistics
Tablica 1. Meteorološki podatci za Muğlu

Months / *Mjeseci*	**5 January to 5 February** *Od 5. siječnja do 5. veljače*	**6 February to 5 March** *Od 6. veljače do 5. ožujka*	**6 March to 5 April** *Od 6. ožujka do 5. travnja*
Maximum temperature per month, °C *najviša mjesečna temperatura,* °C	16.9	21.0	27.3
Avarage temperature per month, °C *prosječna mjesečna temperatura,* °C	6.9	8.1	10.3
Minumum temperature per month, °C *minimalna mjesečna temperatura,* °C	-2.5	-2.7	-0.9
Humidity per month, % *mjesečna vlažnost,* %	83.7	75.6	69.6
Average wind speed per month, m/s *prosječna mjesečna brzina vjetra,* m/s	1.0	0.8	0.9
Total rainfall per month, mm = kg/m^2 *ukupna mjesečna količina padalina,* mm = kg/m^2	225.2	96.9	78.5
Number of rainy days *broj kišnih dana*	16	5	10
Direct intensity of solar radiation, W/m^2 *izravni intenzitet Sunčeva zračenja,* W/m^2	989	1138	1082

Table 2 Color of impregnated and coated specimens before and after weathering
Tablica 2. Boja impregniranih i premazanih uzoraka prije i nakon izlaganja vremenskim utjecajima

Chemicals *Kemikalije*	**Reten-tion values** *Retencija*	**Color of specimens before weathering** *Vrijednosti boje uzoraka prije izlaganja vremenskim utjecajima*			**Color of specimens after weathering** *Vrijednosti boje uzoraka nakon izlaganja vremenskim utjecajima*			**Color change values after weathering** *Vrijednosti promjene boje nakon izlaganja vremenskim utjecajima*			**Total color changes** *Ukupne promjene boje*	
		L^*	a^*	b^*	L^*	a^*	b^*	ΔL^*	Δa^*	Δb^*	ΔE^*	H.G.
Control *kontrolni uzorak*	-	66.42	10.78	20.82	61.85	7.67	23.70	-4.57	-3.11	2.88	6.23	A
EPR	-	46.33	17.70	28.10	52.59	16.22	29.05	6.26	-1.48	0.95	6.50	A
PEG-400+EPR	14.12	27.95	13.57	17.19	46.48	13.21	25.64	18.52	-0.36	8.45	20.35	B
V+EPR	12.26	47.45	14.75	23.82	52.73	13.25	26.59	5.28	-1.50	2.77	6.14	A

Note: 10 specimens were prepared for each group, EPR – epoxy resin, PEG-400 – polyethylene glycole-400, V – vaseline, H.G. – homogeneity groups.
Napomena: Za svaku je grupu pripremljeno deset uzoraka; EPR – epoksidna smola, PEG-400 – polietilen glikol-400, V – vazelin, H. G. – homogene grupe.

ter weathering, specimens treated with EPR, PEG-400+EPR, and V+EPR showed positive ΔL^* values, while the control group showed negative ΔL^* values.

Negative lightness stability values (ΔL^*) indicate that wood darkens following weathering. Darkening of the control group could be attributed to breakdown of non-cellulosic polysaccharides and lignin (Sönmez *et al.* 2011; Hon and Chang, 1985). According to Temiz *et al.* (2005), ΔL^* is a key indicator of wood surface quality. PEG-400+EPR treated specimens had the highest ΔL^* values following weathering. After weathering, red color content decreased and the yellow color content increased for all specimens.

PEG-400+EPR treated specimens had the highest total color change (ΔE^*) and the most negative results for color stability. V+EPR-treated specimens had the least total color change, making them the most stable group. PEG-400+EPR treatment resulted in significantly higher ΔE^* values compared to other groups.

3.2 Adhesion test
3.2. Ispitivanje adhezije

Table 3 lists the adhesion strength values of specimens both before and after weathering.

The results indicate that specimens treated with PEG-400+EPR and V+EPR exhibited significantly lower adhesion strength values compared to those coated solely with EPR. For instance, while the adhesion strength of the EPR-coated specimens was 4.08 N/mm², the values for PEG-400+EPR and V+EPR treated specimens were 1.66 N/mm² and 1.61 N/mm², respectively. This reduction in adhesion strength is consistent with previous findings. Toker *et al.* (2008) reported that the adhesion strength of Calabrian pine (*Pinus brutia* Ten.) pre-impregnated with borates prior to varnish coating decreased due to the weakening of the wood surface. Similar trends were observed in our study, where pre-impregnation before epoxy coating led to a notable decline in adhesion strength. Additionally, Üstün (2019) examined the adhesion strength of wood treated with copper-based compounds and varnished with water-based, synthetic, and polyurethane varnishes, reporting a consistent decline in adhesion strength across all test groups after natural weathering. Similarly, Baysal *et al.* (2021) found that Calabrian pine specimens treated and coated with copper-based compounds experienced a reduction in adhesion strength during weathering. Our results align with these previous studies, further supporting the impact of weathering on adhesion strength reduction.

The findings also reveal that the PEG-400+EPR and V+EPR treatments significantly mitigated the adhesion strength losses of Oriental beech specimens compared to those coated solely with EPR. Among all

Table 3 Adhesion strength values of impregnated and coated specimens before and after weathering
Tablica 3. Vrijednosti adhezijske čvrstoće impregniranih i premazanih uzoraka prije i nakon izlaganja vremenskim utjecajima

Types *Vrste*	**Retention values** *Retencija*	**Adhesion strength before weathering** *Adhezivna čvrstoća prije izlaganja*	**Adhesion strength after weathering** *Adhezivna čvrstoća nakon izlaganja*	**Adhesion strength decrease after weathering** *Smanjenje adhezivne čvrstoće nakon izlaganja*	
		Mean, N/mm²	Mean, N/mm²	%	H. G.
EPR	-	4.08	1.89	-60.53	B
PEG-400+EPR	14.83	1.66	1.23	-25.75	A
V+EPR	11.94	1.61	1.06	-34.16	A

Note: 10 specimens were prepared for each group, EPR – epoxy resin, PEG-400 – polyethylene glycole-400, V – vaseline, H.G. – homogeneity groups.
Napomena: Za svaku je grupu pripremljeno deset uzoraka; EPR – epoksidna smola, PEG-400 – polietilen glikol-400, V – vazelin, H. G. – homogene grupe.

Table 4 Results of oven and air-dry densities test of impregnated and coated specimens
Tablica 4. Rezultati ispitivanja gustoće impregniranih i premazanih uzoraka prije i nakon izlaganja vremenskim utjecajima

Types *Vrste*	**Retention values** *Retencija*	**Oven-dry density, g/cm³** *Gustoća drva u apsolutno suhom stanju, g/cm³*	**Increase compared to control, %** *Povećanje u odnosu prema kontrolnim uzorcima, %*	**Std. dev.**	**H.G.**	**Air-dry density, g/cm³** *Gustoća drva sušenoag na zraku, g/cm³*	**Increase compared to control, %** *Povećanje u odnosu prema kontrolnim uzorcima, %*	**Std. dev.**	**H.G.**
Control	-	0.62	-	0.04	A	0.67	-	0.04	A
EPR	-	0.70	12.90	0.09	B	0.72	7.46	0.87	B
PEG-400+EPR	14.09	0.78	25.80	0.03	B	0.80	19.40	0.02	B
V+EPR	14.47	0.74	19.35	0.02	B	0.81	20.89	0.22	B

Note: 10 specimens were prepared for each group, EPR – epoxy resin, PEG-400 – polyethylene glycole-400, V – vaseline, Std. dev. – Standard deviation, H.G. – homogeneity groups.
Napomena: Za svaku je grupu pripremljeno deset uzoraka; EPR – epoksidna smola, PEG-400 – polietilen glikol-400, V – vazelin, Std. dev. – standardna devijacija, H. G. – homogene grupe.

treatments, specimens coated only with EPR exhibited the most substantial decrease of 60.53 % in adhesion strength after weathering, whereas the PEG-400+EPR treatment proved to be the most effective, limiting the reduction to only 25.75 %. This suggests that the addition of PEG-400 and vaseline may enhance the durability of epoxy coatings under weathering conditions. However, it is important to note that the pre-impregnation process applied before epoxy coating significantly contributed to the reduction in adhesion strength, highlighting the potential limitations of this approach.

3.3 Oven-dry and air-dry densities test
3.3. Gustoća drva u apsolutno suhom stanju i gustoća drva sušenoga na zraku

Table 4 gives the oven and air-dry densities of specimens impregnated with PEG-400 and vaseline and coated with EPR.

Table 4 illustrates the results of the oven and air-dry density tests performed on EPR-coated specimens impregnated with PEG-400 and V. Density influences the mechanical and physical properties of wood and wood-derived products. In fact, density has a positive relationship with wood mechanical properties, such as hardness, abrasion resistance, and heat value (Kollmann and Cote, 1968). Our findings indicated that the control group had the lowest oven-dry and air-dry density values. The oven-dry and air-dry densities of the control group were 0.62 and 0.67 g/cm³. According to our findings, the maximum oven-dry density value for PEG-400+EPR treated specimens was 0.78 g/cm³, while the highest air-dry density for V+EPR treated specimens was 0.81 g/cm³. The impregnated and coated specimens had greater oven-dry and air-dry density values compared to the control group, ranging from 12.90 % to 25.80 % and 7.46 % to 20.89 %, respectively. Statistically significant differences were seen in the oven-dry and air-dry density values of the EPR, PEG-400+EPR, and V+EPR treatment groups compared to the control group.

3.4 Water absorption test
3.4. Ispitivanje upijanja vode

The WA values of specimens impregnated with polyethylene glycole-400 (PEG-400) and vaseline (V) and coated with epoxy resin (EPR) are given in Table 5.

Wood specimens absorb more water in the early phase than in subsequent phases, according to previous studies (Alma, 1991; Hafızoğlu *et al.,* 1994; Yıldız, 1994). The entry of WA into the wood accessible empty pores at the beginning of the soaking procedure and the gradual shrinkage of those wood spaces could be the cause of these results. As an illustration, in the first two hours the WA rate of the control group was 45.45 %,

Table 5 WA values of impregnated and coated specimens
Tablica 5. WA vrijednosti impregniranih i premazanih uzoraka

Types *Vrste*	**Retention values** *Retencija*	***WA, %***													
		2 h	H.G.	6 h	H.G.	14 h	H.G.	30 h	H.G.	62 h	H.G.	94 h	H.G.	126 h	H.G.
Control	-	45.45	C	54.27	B	62.13	B	68.72	B	74.13	B	75.52	B	78.33	B
EPR	-	27.60	B	33.39	A	41.46	A	44.22	A	48.61	A	50.40	A	51.71	A
PEG-400+EPR	16.10	18.22	A	23.52	A	35.15	A	40.50	A	45.11	A	47.35	A	49.80	A
V+EPR	12.45	25.26	AB	32.96	A	41.03	A	46.03	A	49.77	A	52.81	A	52.80	A

Note: 10 specimens were prepared for each group, EPR – epoxy resin, PEG-400 – polyethylene glycole-400, V – vaseline, H. G. – homogeneity groups.
Napomena: Za svaku je grupu pripremljeno deset uzoraka; EPR – epoksidna smola, PEG-400 – polietilen glikol-400, V – vazelin, H. G. – homogene grupe.

which is greater than half the rate of 78.33 % in the subsequent 126 hours. In comparison to the impregnated and coated specimens, the control group absorbed more water during each of the water absorption periods.

The water repelling and bulking qualities of the chemicals used contribute significantly to the reduction in WA. Untreated control specimens absorbed 78.33 % of their mass in water, whereas impregnated and coated Oriental beech absorbed 49.80-52.80 %. The hydrophobic properties of impregnated and coated specimens, which cover the wood surface and remain in the cell wall and lumen, cause reduced water penetration into wood (Chao and Lee, 2003). PEG-400+EPR treated specimens absorbed the least amount of water during all water absorption periods.

Reduced water absorption plays a crucial role in improving the resistance of wood against weathering effects. Since weathering involves prolonged exposure to moisture, temperature fluctuations, and UV radiation, limiting water absorption reduces swelling and shrinkage cycles, which can lead to cracks and mechanical deterioration. The hydrophobic properties of EPR, PEG-400+EPR, and V+EPR treatments provide a protective barrier, minimizing water uptake and thereby decreasing the risk of fungal attack, surface erosion, and degradation over time. PEG-400+EPR-treated specimens exhibited the lowest water absorption levels, indicating enhanced protection against moisture-induced deterioration, making them more resistant to environmental weathering.

In treated wood specimens, the amount of water absorbed can be limited or decreased by the movement of polyethylene glycol molecules into the swelling cell wall (Stamm, 1964). In this sense, specimens treated with PEG-400+EPR outperformed other treatments in terms of water absorption. Between the control group and the EPR, PEG-400+EPR, and V+EPR treatment groups, there were statistically significant variations in WA values at all WA intervals. Furthermore, WA values were not substantially different across the EPR-coated, PEG-400+EPR, and V+EPR treated groups.

4 CONCLUSIONS
4. ZAKLJUČAK

This study investigated some physical and surface properties of impregnated and coated Oriental beech wood, focusing on some physical tests such as oven-dry density, air-dry density, and water absorption tests, and some surface tests such as color and adhesion strength tests under weathering conditions.

Specimens impregnated with vaseline and coated with epoxy resin (EPR) exhibited the best color stability, maintaining positive lightness stability throughout the weathering period. Chemical impregnation and weathering resulted in the loss of adhesion strength. However, adhesion strength losses of impregnated and EPR-coated specimens were lower than those of specimens coated only with EPR after weathering.

Chemical impregnation and protective coatings notably increased the oven-dry and air-dry densities of the wood while substantially reducing water absorption across all testing periods. However, the combination of PEG-400 impregnation and EPR coating yielded less favorable results in terms of color stability, oven-dry density, and air-dry density. Despite these limitations, the PEG-400+EPR treatment performed well in reducing WA and preserving adhesion strength, suggesting its potential applicability for specific use cases.

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