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INVESTIGATION LEACHING PERFORMANCE OF WOOD MATERIALS COATED WITH *COTINUS COGGYGRIA* EXTRACTS AND LIQUID GLASS (SiO_2) MIXTURE

Mehmet Yeniocak, Suleyman Kahveci
Mugla Sitki Kocman University, Faculty of Technology
Department of Woodworking Industrial Engineering
Mugla, Turkey

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ABSTRACT

The purpose of this study was to develop durable natural colorant modified with liquid glass (SiO_2) to be used on wooden materials and determine their desorption performance using the leaching method. For this purpose, the natural colorant was extracted from the smoke tree (*Cotinus coggygria*) performing boiling method. Then, mordants; oak ash (3% by weight), and vinegar (10% by weight) (CH_3COOH) were added to mixture. As the last, liquid glass (20% by weight) were added to mixture. The obtained mixture was applied to the Scots pine (*Pinus sylvestris* L.) and beech (*Fagus orientalis*) wood samples by using classic dipping and vacuum method. Leaching test was performed at pH3-22°C, at pH7-10°C, 22°C, 40°C and at pH 11-22°C. The results showed that the liquid glass did not protect wood materials in leaching as planned. The effective results can be obtained by changing the application method and amount of the liquid glass. The nature-based colorants can be an eco-friendly alternative to synthetics.

KEYWORDS: Natural dye, smoke tree, liquid glass, leaching.

INTRODUCTION

The wood material offers many alternatives to valuable convenience for humankind. Wood materials have been using almost everywhere in our life, as the phrase goes from the cradle to the grave. It serves humanity such as home, voice, toys, aesthetic, technology, embrace, arts or fashion. It is a priceless gift of nature. Besides all that advantages, wood could destroy by effects biological, physical, chemical during the utilization. At this point, wood material needs to protect against these destructors. We have used various chemical substances to protect and extend serving life of the wood. On the other hand, these chemicals adversely affect human health and environment due to the volatile organic compounds (VOCs) they contain.

According to current European Union (EU) regulations, synthetic dyes based on benzidine, 3,3′-dimethoxybenzidine and 3,3′-dimethylbenzidine have been classified as carcinogens of category 2, that is, as "substances which should be regarded as if they are carcinogenic to man" (Golka et al. 2004).

With the increase in social and political pressure on the environment, countries are set to implement more stringent act and regulation to manage these hazards. In addition to this, with the increase sensitivity about nature increases the demand on environmentally friendly wood preservatives all over the world over.

In recent years, various scientific studies were performed on developing natural sources as protector for wood materials. Ozen et al. (2014a) antifungal and antimicrobial properties of madder root, Yeniocak et al. (2015) color stability of red beetroot, Colak et al. (2015) antifungal and antimicrobial properties of indigo, Goktas et al. 2009ab, 2008, have studied, color stability of saffron, madder root and laurel, Ozen et al. (2014b) colorability wood material with *Punica granatum* and *Morus nigra* extracts, Yeniocak et al. (2016) fire resistant performance of *Punica granatum* extracts on wood surfaces. These studies showed that the natural dyes can be used as an alternative to synthetics on wood surfaces. Goktas et al. (2013), have studied leaching performance of *Rubia tinctorium*, *Rhamnus petiolariss*, *Juglans regia* L., *Boreava orientalis*, *Lawsonia inermis* L., *Carthamus tinctorius* L., *Indigo feratinctoria* L., and *Beta vulgaris* paints on different wood types. They reported that; leaching performance of all natural dyes was not found good enough to be used in outdoor conditions.

The main idea of this study was to improve the leaching performance of wood material with liquid glass (SiO_2) and to color the wood material with smoke tree extracts in mean while. The leaves and the hardwood of smoke tree are used for the dyeing of leather, wool and silk into a yellowish colour (Gajić 1975). The leaves and young branches were utilized for the production of essential oil with a terpeni colour for use in perfumery (Tsankova et al. 1993). Liquid glass (SiO_2) is a flexible and breathable glass coating with approximately 100 nanometers thick (500 times thinner than a human hair). It is food safe, environmentally friendly (winner of the Green Apple Award) and it can be applied to almost any surface within seconds. Once coated, creates surfaces easy to clean and anti- microbial protected (Winner of the NHS Smart Solutions Award). Houses, cars, ovens, wedding dress or any other protected surface become stain resistant and can be easily cleaned with water; no cleaning chemicals are required (Ecocorpacia 2018).

In this study, we focused on the coloring wood material using smoke tree extract (natural colorant) + mordants (oak ash and vinegar) + liquid glass and determined effect of liquid glass on leaching performance.

MATERIAL AND METHODS

Wood materials

Wood blocks were cut from straight-grained Scots pine (*Pinus sylvestris* L.) and beech (*Fagus orientalis*) timber with 19 x 19 x 19 mm dimensions. Five replicate blocks were cut for each dye solution. The samples were kept under laboratory conditions (20 ± 2°C) and suitable moisture (moisture of ±12% and relative moisture content of ±65%) conditions for 24 hours.

Preparation bio-colorant and mordant agents

The smoke tree was purchased from the local store located in Mugla, (Turkey). The flowers of the smoke trees (5% by weight) were poured into 45°C temperature water and extraction were

performed for 180 min. time. At the end of the extraction time, the evaporated water was added to the solution and the plant residues were filtered off. To obtain different color options and to improve binding, extracts were mixed with grape vinegar (10% by weight) (CH_3COOH) and oak ash (3% by weight) mordant. As the final step, the liquid glass (20% by weight) was added to suspension.

Dyeing test samples

The smoke tree extracts + liquid glass mixture was applied to wood blocks by classic dipping and vacuum-assisted impregnation (ASTM-D 1413-76) methods. Application was performed in accordance of Tab. 1. Retention ($kg \cdot m^{-3}$) of smoke tree concentrations and weight gain of wood material (%) were calculated with the following equations:

$$R = \frac{G.C}{V} \; x \; 10 (kg \cdot m^{-1}) \quad (1)$$

$$Weight\ gain = \frac{W_t - W_i}{W_i} \; x \; 100 \quad (\%) \quad (2)$$

where: G - amount of solution absorbed by wood that is calculated by T2 -T1,
T2 - masses of wood after impregnation (g),
T1- masses of wood before impregnation (g),
C - solution concentration (%),
V - volume of the specimen (cm^3),
W_t -final conditioned weight of a wood block (kg),
W_i - initial weight (kg).

Tab. 1: Application parameters

Colorant	Method	Temprature (°C)	Time (Min.)
Smoke tree	Dipping	45	60
Smoke tree+ liquid glass			
Smoke tree	Vacuum-assisted impregnation	-	According to ASTM-D 1413-76
Smoke tree + liquid glass		-	According to ASTM-D 1413-76

Leaching test procedure

The bio-colorant coated wood samples were stored in the owen until equilibrium. The maximum wave length determined from each solution in UV spectrophotometer to use as reference point for absorbance. Three samples from each group were placed into Erlenmeyer flask in 250 ml distilled water. Erlenmeyer flasks placed into rinsing bath shaken during 120 minutes. In 5, 15, 30, 45, 60, 75, 90, 120 minutes some water was taken to get absorbance inside, in reference of maximum wave length of each colorant. Leach water was held at different temperature (10°C, 22°C, 40°C), and pH (3, 7, 11) to compare t-effect on leaching rate. Leaching test method and parameters used in procedure were developed by the project team by calculating the effects that the material could be exposed to under different ambient and weather conditions.

RESULTS AND DISCUSSION

Retention rates

The retention rates and amounts of smoke tree-mordant and liquid glass mixes given in Tab. 2. Retention is an important parameter for dyeing and impregnation to determine the amount of substance bonded on wood material.

Tab. 2: Retention amounts ($kg \cdot m^{-3}$) and rates (%).

Dye	Mordant	Solution	Scots pine				Beech			
			Dipping		Vacuum		Dipping		Vacuum	
			Mean	St.dev.	Mean	St.dev.	Mean	St.dev.	Mean	St.dev.
Smoke tree ($kg \cdot cm^{-3}$)	Control	With liquid glass	0.33	0.04	0.81	0.04	0.67	0.07	1.37	0.39
		Without liquid glass	0.20	0.07	0.48	0.08	0.36	0.04	1.28	0.31
	Oak ash	With liquid glass	0.29	0.08	0.66	0.07	0.67	0.16	1.54	0.12
		Without liquid glass	0.16	0.03	0.47	0.12	0.38	0.04	1.15	0.09
	Vinegar	With liquid glass	0.35	0.03	0.91	0.08	0.75	0.08	1.95	0.18
		With liquid glass	0.23	0.04	0.46	0.02	0.47	0.04	1.75	0.09
Smoke tree (%)	Control	With liquid glass	1.34	0.31	2.29	0.18	1.28	0.23	2.39	0.25
		Without liquid glass	2.08	0.20	2.21	0.10	1.31	0.29	2.38	0.35
	Oak ash	With liquid glass	2.54	0.11	3.19	0.39	1.97	0.11	3.49	0.54
		Without liquid glass	2.29	0.14	2.50	0.27	1.96	0.09	3.31	0.40
	Vinegar	With liquid glass	1.47	0.31	2.82	0.19	1.93	0.05	2.05	0.13
		Without liquid glass	1.25	0.11	3.78	0.39	1.95	0.54	2.08	0.26

According to Tab. 2 the retention amount ($kg \cdot m^3$) obtained from the vacuum method found higher than the dipping method as expected. The maximum hold was determined in the vinegar mordant group mixed with liquid glass in both types of wood.

When the retention percentages are examined; it was found that the amount of adhesion was higher in the groups applied with the vacuum method compared to dipping method.

The maximum wavelength and color intensity between wavelengths were determined using UV spectrophotometer for smoke tree and mordanting solutions (Tab. 3).

Tab. 3: Maximum wave lengths of colorant.

Colorant	Max. wave light (nm)
Control (Smoke tree)	218
Control (Smoke tree with Liquid glass)	210
Smoke tree + Oak ash	209
Smoke tree + Oak ash with liquid glass	210
Smoke tree + Vinegar	201
Smoke tree + Vinegar with liquid glass	232

Maximum wave lengths of solutions were used as a reference point during measuring the absorbance of leaching in varied time on UV spectrophotometer. Leaching test was conducted in parameters pH3 – 22°C, pH7 – 10, 22°C and 40 °C and pH 11, 22 °C.

Results for leaching in pH:3 and 22°C

The leaching test results (under conditions pH: 3 and 22°C temperature) were given at Tab. 4 in unit of absorbance (abs) .

Tab. 4: Leaching test results under conditions pH:3 and 22 °C temperature (abs).

Method	Wood type	Mordant	Solution	Leaching time (minute)						
				5	15	30	60	75	90	120
Dipping	Scots pine	Control	With liquid glass	0.292	0.419	0.561	0.732	0.797	0.862	0.964
			Without liquid glass	0.324	0.447	0.568	0.714	0.758	0.803	0.888
		Oak ash	With liquid glass	0.351	0.464	0.567	0.695	0.750	0.786	0.871
			Without liquid glass	0.365	0.472	0.537	0.697	0.741	0.772	0.824
		Vinegar	With liquid glass	0.264	0.394	0.519	0.682	0.752	0.813	0.905
			Without liquid glass	0.279	0.389	0.494	0.587	0.633	0.676	0.744
	Beech	Control	With liquid glass	0.303	0.400	0.500	0.618	0.667	0.715	0.792
			Without liquid glass	0.251	0.324	0.392	0.472	0.507	0.536	0.588
		Oak ash	With liquid glass	0.254	0.302	0.348	0.399	0.412	0.433	0.458
			Without liquid glass	0.272	0.327	0.378	0.467	0.478	0.504	0.548
		Vinegar	With liquid glass	0.239	0.329	0.395	0.500	0.546	0.587	0.663
			Without liquid glass	0.238	0.326	0.389	0.492	0.534	0.566	0.626
Vacuum	Scots pine	Control	With liquid glass	0.279	0.413	0.567	0.741	0.811	0.880	0.991
			Without liquid glass	0.305	0.437	0.557	0.694	0.741	0.787	0.873
		Oak ash	With liquid glass	0.476	0.609	0.729	0.902	0.963	1.032	1.133
			Without liquid glass	0.577	0.796	1.00	1.260	1.347	1.432	1.582
		Vinegar	With liquid glass	0.307	0.435	0.570	0.767	0.847	0.913	1.029
			Without liquid glass	0.403	0.578	0.726	0.898	0.976	1.039	1.148
	Beech	Control	With liquid glass	0.252	0.346	0.450	0.586	0.645	0.712	0.816
			Without liquid glass	0.252	0.329	0.404	0.492	0.527	0.564	0.624
		Oak ash	With liquid glass	0.422	0.563	0.682	0.843	0.907	0.966	1.057
			Without liquid glass	0.513	0.703	0.857	1.056	1.120	1.183	1.290
		Vinegar	With liquid glass	0.326	0.488	0.627	0.825	0.905	0.975	1.018
			Without liquid glass	0.270	0.359	0.440	0.546	0.596	0.636	0.706

According to results, at the end of the 120 minutes; both Scots pine and beech samples dyed by dipping method was showed lower leaching performance than vacuum method. In the dipping method the minimum leaching was seen at the group of without addition liquid glass and vinegar (0.744 abs), maximum leaching was obtained in control group (0.964 abs). On the other hand, minimum leach obtained in control group and maximum leaching monitored in the group of mordanted with oak ash + without liquid glass mixes applied with the vacuum method.

For beech wood samples applied with dipping method, minimum leach measured on the group of mordanted with oak ash with liquid glass addition (0.458 abs) and maximum leaching watched in liquid glass added control group (0.792 abs). In the vacuum method, minimum leaching performed in the samples of control without addition liquid glass (0.624).

Results for leaching in pH: 7 and 10 °C

The results of leaching test (under conditions pH:7 and 10°C temperature) were given at Tab. 5 in unit of absorbance (abs).

Tab. 5: Leaching test results under conditions pH:7 and 10°C temperature (abs).

Method	Wood type	Mordant	Solution	Leaching time (minute)						
				5	15	30	60	75	90	120
Dipping	Scots pine	Control	With liquid glass	0.267	0.435	0.535	0.657	0.703	0.748	0.811
			Without liquid glass	0.265	0.406	0.475	0.550	0.587	0.618	0.664
		Oak ash	With liquid glass	0.274	0.340	0.399	0.504	0.512	0.549	0.608
			Without liquid glass	0.313	0.389	0.462	0.578	0.609	0.665	0.719
		Vinegar	With liquid glass	0.206	0.234	0.312	0.397	0.442	0.477	0.536
			Without liquid glass	0.214	0.277	0.345	0.430	0.470	0.494	0.542
	Beech	Control	With liquid glass	0.265	0.404	0.466	0.562	0.598	0.638	0.694
			Without liquid glass	0.209	0.299	0.352	0.407	0.437	0.456	0.494
		Oak ash	With liquid glass	0.245	0.293	0.333	0.407	0.418	0.453	0.492
			Without liquid glass	0.237	0.275	0.312	0.376	0.390	0.429	0.452
		Vinegar	With liquid glass	0.235	0.291	0.368	0.470	0.518	0.558	0.631
			Without liquid glass	0.189	0.232	0.284	0.342	0.368	0.387	0.427
Vacuum	Scots pine	Control	With liquid glass	0.223	0.325	0.414	0.526	0.578	0.636	0.718
			Without liquid glass	0.256	0.364	0.430	0.512	0.554	0.591	0.636
		Oak ash	With liquid glass	0.430	0.558	0.679	0.811	0.875	0.950	1.022
			Without liquid glass	0.434	0.593	0.731	0.948	0.981	1.107	1.150
		Vinegar	With liquid glass	0.239	0.302	0.394	0.526	0.585	0.631	0.723
			Without liquid glass	0.260	0.341	0.420	0.515	0.557	0.590	0.648
	Beech	Control	With liquid glass	0.227	0.321	0.390	0.474	0.516	0.557	0.618
			Without liquid glass	0.201	0.285	0.313	0.360	0.388	0.405	0.442
		Oak ash	With liquid glass	0.406	0.512	0.624	0.786	0.842	0.922	1.020
			Without liquid glass	0.514	0.687	0.790	0.951	1.109	1.129	1.214
		Vinegar	With liquid glass	0.231	0.303	0.389	0.494	0.545	0.585	0.656
			Without liquid glass	0.208	0.257	0.314	0.388	0.412	0.437	0.483

For 120 minutes leaching (Tab. 5); Scots pine treated by dipping method was shown the best leaching performance onto group vinegar + liquid glass as 0.536 abs. The worst leaching was seen at the group treated with control+ liquid glass as 0.811 abs. On Scots pine group treated by vacuum method; minimum leach was seen as 0.636 abs on samples of control + without liquid glass and maximum leach obtained on samples of treated with oak ash + without liquid glass.

Minimum leaching value was founded in the group of vinegar + without liquid glass (0.427 abs) for the beech samples applied by dipping method. Maximum leaching performance was seen on control + liquid glass samples (0.694 abs). Minimum leaching value was seen in vacuum method on the group of control + without liquid glass (0.442 abs), and the maximum leaching performed on group of oak ash + without liquid glass.

Results for leaching in pH: 7and 22°C

Results of leaching test under conditions pH:7 and 22°C temperature given at Tab. 6 in unit of absorbance (abs).

Tab. 6: Leaching test results under conditions pH:7 and 22 ˚C temperature (abs).

Method	Wood type	Mordant	Solution	Leaching time (minute)						
				5	15	30	60	75	90	120
Dipping	Scots pine	Control	With liquid glass	0.341	0.466	0.635	0.813	0.902	0.951	1.045
			Without liquid glass	0.321	0.452	0.565	0.728	0.761	0.802	0.872
		Oak ash	With liquid glass	0.325	0.434	0.548	0.663	0.722	0.774	0.834
			Without liquid glass	0.424	0.496	0.631	0.799	0.858	0.914	1.013
		Vinegar	With liquid glass	0.251	0.370	0.501	0.638	0.712	0.743	0.826
			Without liquid glass	0.273	0.383	0.491	0.616	0.675	0.714	0.781
	Beech	Control	With liquid glass	0.329	0.457	0.605	0.771	0.858	0.907	1.009
			Without liquid glass	0.252	0.342	0.410	0.524	0.544	0.575	0.632
		Oak ash	With liquid glass	0.235	0.290	0.356	0.410	0.452	0.462	0.495
			Without liquid glass	0.280	0.321	0.381	0.470	0.497	0.537	0.591
		Vinegar	With liquid glass	0.251	0.363	0.470	0.619	0.705	0.745	0.847
			Without liquid glass	0.228	0.305	0.372	0.458	0.496	0.527	0.572
Vacuum	Scots pine	Control	With liquid glass	0.278	0.404	0.584	0.793	0.886	0.971	1.062
			Without liquid glass	0.316	0.452	0.568	0.744	0.775	0.824	0.912
		Oak ash	With liquid glass	0.585	0.722	0.906	1.100	1.203	1.260	1.385
			Without liquid glass	0.523	0.774	1.010	1.233	1.280	1.359	1.512
		Vinegar	With liquid glass	0.315	0.484	0.646	0.826	0.921	0.969	1.076
			Without liquid glass	0.325	0.455	0.571	0.721	0.783	0.828	0.910
	Beech	Control	With liquid glass	0.253	0.346	0.476	0.648	0.733	0.799	0.910
			Without liquid glass	0.252	0.348	0.429	0.563	0.598	0.643	0.718
		Oak ash	With liquid glass	0.409	0.563	0.692	0.837	0.915	0.951	1.051
			Without liquid glass	0.503	0.707	0.895	1.120	1.201	1.278	1.411
		Vinegar	With liquid glass	0.316	0.450	0.585	0.771	0.871	0927	1.057
			Without liquid glass	0.256	0.353	0.441	0.549	0.600	0.637	0.704

According to the results at the end of the 120 minutes time; in both wood type Scots pine and beech samples dyed by dipping method was showed better leaching performance than vacuum method. Minimum leaching was seen on Scots pine samples applied by dipping method at the group of without addition liquid glass and vinegar (0.781 abs), maximum leaching was obtained in control+ with liquid glass group (1.045 abs). On the other hand, minimum leach obtained in group treated with vinegar + without liquid glass (0.910 abs) and maximum leaching monitored in the group of mordanted with oak ash + without liquid glass mixes (1.512 abs) applied with the vacuum method.

For beech wood samples applied with dipping method, minimum leach viewed on the group of mordanted with oak ash with liquid glass addition (0.495 abs) and maximum leaching watched in liquid glass added control group (1.009 abs). In the vacuum method, minimum leaching performed in the samples of vinegar + without addition liquid glass (0.704 abs) and maximum leach on group of oak ash + liquid glass mixing as (1.411 abs).

Results for leaching in pH: 7and 40˚C

Results of leaching test under conditions pH:7 and 40˚C temperature given at Tab. 7 in unit of absorbance (abs).

Tab. 7: Leaching test results under conditions pH:7 and 40°C temperature (abs).

Method	Wood type	Mordant	Solution	Leaching time (minute)						
				5	15	30	60	75	90	120
Dipping	Scots pine	Control	With liquid glass	0.446	0.760	0.992	1.257	1.374	1.480	1.619
			Without liquid glass	0.392	0.555	0.681	0.862	0.917	0.975	1.057
		Oak ash	With liquid glass	0.478	0.663	0.822	1.020	1.124	1.182	1.303
			Without liquid glass	0.563	0.800	0.989	1.244	1.359	1.450	1.598
		Vinegar	With liquid glass	0.451	0.769	0.996	1.267	1.378	1.444	1.569
			Without liquid glass	0.486	0.758	0.942	1.172	1.264	1.335	1.455
	Beech	Control	With liquid glass	0.426	0.607	0.753	0.948	1.033	1.121	1.237
			Without liquid glass	0.364	0.504	0.611	0.752	0.820	0.874	0.956
		Oak ash	With liquid glass	0.305	0.395	0.469	0.572	0.636	0.670	0.743
			Without liquid glass	0.343	0.458	0.553	0.693	0.755	0.807	0.894
		Vinegar	With liquid glass	0.383	0.559	0.692	0.888	0.977	1.039	1.168
			Without liquid glass	0.306	0.422	0.504	0.620	0.670	0.716	0.789
Vacuum	Scots pine	Control	With liquid glass	0.438	0.733	0.996	1.347	1.503	1.643	1.829
			Without liquid glass	0.441	0.642	0.797	0.990	1.080	1.142	1.241
		Oak ash	With liquid glass	0.808	1.153	1.437	1.820	1.980	2.097	2.308
			Without liquid glass	0.880	1.252	1.578	1.972	2.129	2.279	2.450
		Vinegar	With liquid glass	0.677	1.003	1.220	1.501	1.609	1.697	1.847
			Without liquid glass	0.597	0.852	1.033	1.268	1.359	1.439	1.575
	Beech	Control	With liquid glass	0.404	0.631	0.840	1.147	1.298	1.448	1.665
			Without liquid glass	0.380	0.537	0.673	0.842	0.926	1.000	1.110
		Oak ash	With liquid glass	0.572	0.757	0.939	1.152	1.243	1.331	1.457
			Without liquid glass	0.718	0.966	1.182	1.444	1.570	1.660	1.814
		Vinegar	With liquid glass	0.520	0.799	1.017	1.356	1.499	1.614	1.830
			Without liquid glass	0.358	0.501	0.602	0.761	0.821	0.880	0.987

Taking into consideration 120 minutes in leaching, when Tab. 7 is examined; Scots pine treated by dipping method was shown the best leaching performance onto group control + without liquid glass (1.057 abs). The worst leaching was seen at the group treated with control + liquid glass (1.619 abs). Leaching performance of Scots pine in groups treated with vacuum method; minimum leach seen as 1.214 abs on samples of control + without liquid glass and the maximum leach obtained on samples of treated with oak ash + without liquid glass (2.450 abs).

In wood type of beech and in application method of dipping the minimum leaching value founded in group of oak + with liquid glass (0.743 abs). Maximum leaching performance was seen on control + liquid glass samples as 1.237 abs. Minimum leaching value was seen in vacuum method on the group of vinegar + without liquid glass (0.987 abs), and the maximum leaching performed on group of vinegar + without liquid glass (1.830 abs).

Results for leaching in pH: 11 and 22°C

Results of leaching test under conditions pH:11 and 22°C temperature given at Tab. 8 in unit of absorbance (abs).

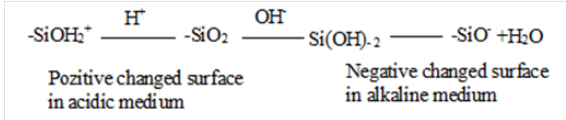
Tab. 8: Leaching test results under conditions pH:11 and 22°C temperature (abs).

Method	Wood type	Mordant	Solution	Leaching time (minute)						
				5	15	30	60	75	90	120
Dipping	Scots pine	Control	With liquid glass	0.421	0.645	0.716	0.896	0.988	1.055	1.115
			Without liquid glass	0.400	0.514	0.622	0.715	0.802	0.934	0.997
		Oak ash	With liquid glass	0.399	0.579	0.669	0.771	0.812	0.889	0.913
			Without liquid glass	0.448	0.697	0.798	0.864	0.928	0.997	1.050
		Vinegar	With liquid glass	0.401	0.611	0.867	0.925	0.998	1.044	1.103
			Without liquid glass	0.389	0.588	0.800	0.908	1.005	1.032	1.084
	Beech	Control	With liquid glass	0.396	0.549	0.754	0.884	0.947	1.002	1.098
			Without liquid glass	0.294	0.401	0.578	0.689	0.766	0.879	0.949
		Oak ash	With liquid glass	0.254	0.397	0.450	0.601	0.696	0.748	0.802
			Without liquid glass	0.289	0.387	0.501	0.607	0.700	0.794	0.854
		Vinegar	With liquid glass	0.297	0.406	0.641	0.787	0.894	0.989	1.124
			Without liquid glass	0.241	0.394	0.434	0.541	0.674	0.784	0.888
Vacuum	Scots pine	Control	With liquid glass	0.402	0.628	0.889	0.905	1.015	1.101	1.174
			Without liquid glass	0.411	0.701	0.864	0.945	1.087	1.132	1.204
		Oak ash	With liquid glass	0.758	0.984	1.120	1.205	1.311	1.406	1.501
			Without liquid glass	0.815	0.998	1.105	1.219	1.348	1.437	1.528
		Vinegar	With liquid glass	0.666	0.869	0.964	1.089	1.141	1.259	1.341
			Without liquid glass	0.602	0.809	0.974	1.122	1.204	1.271	1.312
	Beech	Control	With liquid glass	0.367	0.588	0.748	0.974	1.120	1.224	1.344
			Without liquid glass	0.314	0.572	0.707	0.879	0.964	1.045	1.102
		Oak ash	With liquid glass	0.511	0.687	0.896	0.997	1.102	1.217	1.369
			Without liquid glass	0.687	0.867	0.994	1.099	1.244	1.356	1.427
		Vinegar	With liquid glass	0.444	0.778	0.986	1.106	1.208	1.299	1.334
			Without liquid glass	0.396	0.659	0.889	0.947	1.098	1.190	1.244

In accordance with results given in Tab. 8 after 120 minutes leaching with application dipping, the best leach evaluated on Scots pine and on beech wood samples respectively, 0.913 abs and 0.802 abs on group of oak ash + with liquid glass. The worst leaching obtained for Scots pine with group control + with liquid glass (1.115 abs) and for beech on group vinegar + with liquid glass as of (1.124 abs). Increase the value of vacuum method, minimum leaching monitored for both Scots pine and beech wood respectively as of 1.174 abs and 1.102 abs on group of control + with liquid glass. Maximum leaching also found in same group oak ash + without liquid glass for Scots pine and beech wood samples separately (1.528 abs) and (1.427 abs).

General leaching performance graphic given at the Fig. 1. In general picture; the increase in temperature is proportional to leaching performance. Increasing of temperature was caused by the further opening of the wood material's pores and by the desertion of the wood material which was held there. It may be also possible to dissolve in some extractives in wood material with temperature effect.

Factor of pH play an important role on leaching performance. Leaching were observed at least on pH:3, while the maximum leaching monitored at pH: 11. In the acidic environment, while the dyestuff attached to the wood material undergoes less desorption, the opposite is true in the alkaline environment. Unfortunately, the liquid glass (SiO_2) did not show the expected protection effect in leaching. It is well known that dying processes depend highly on pH because of the high sensitivity of functional groups on wood surfaces to hydrogen and hydroxyl ions. The observed higher dying performance at the low pHs can be attributed to be active sites over surface on wood materials. Silicon oxides in liquid glass can ionize as follows in acidic and alkaline conditions (Ugurlu et al. 2005):



As expected, tree species showed differences in leaching results. In general, more desorption than the beech type. The leachability depends on chemical properties and the extractives which includes of wood species. Chemical composition and extractives are affected how chemical bonding is strong between wood material and plant extraction. Generally, dyes hold on to the wood surfaces in two ways with physical and chemical bonding. Dyes bonded by physical bonding could separable by leaching from the surfaces easily but chemical bonders are form in a permanent color on wood material.

It is obvious that the samples which were applied by the vacuum method showed bad leaching performance than the samples which were applied by the classical immersion method. When the retention ratios were taken into consideration, it is clearly seen that more dyeing materials are attached to the wood material in practiced by the vacuum method. The excess of leaching in the group applied by vacuum method may be due to the physical bonding of the dye agent to the surface. The dying materials, which is physically adhered to the surface were dissolved in water and undergoes more desorption. The leaching efficiency is shown in Fig. 1.

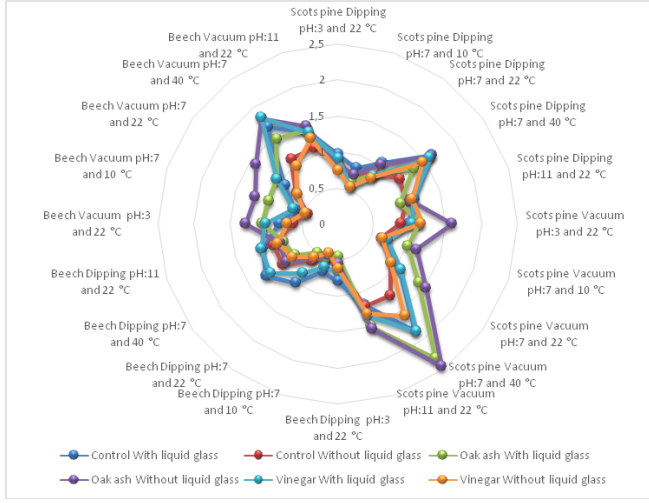


Fig. 1: General picture of leaching performance.

Mordant agents have been effective in leaching. It was observed that the vinegar group and the control group gave close leaching values, but the oak ash group was leached more. In mordanting made with oak ash, the solubilized solution has a larger particle size, which increases the amount of material physically adhered to the surface. This substance on the surface caused the amount of desorption to be measured more.

All that results were existing literature indicated that factors such as temperature, pH, wood and treatment cycles can influence leaching (Dahlgren 1975, Warner and Solomon, 1990, Cooper 1991, 1994, Van Eetvelde et al. 1995a, b, 1998 Breslin and Adler-Ivanbrook 1998, Hingston et al. 2000, Hingston et al. 2002).

CONCLUSIONS

Wood material coated with smoke tree and mordant extractions mixed with liquid glass (SiO_2), afterwards leaching tests was performed in conditions pH3-22˚C, at pH7-10˚C and 22˚C, 40˚C and at pH 11-22˚C.

A number of interesting conclusions may be drawn from this work. In general evaluation, liquid glass, increased the leaching performance around 8.72% based on samples without liquid glass. But; unfortunately, the liquid glass did not show enough protection mechanism in leaching as we expected. Perhaps, instead of mixing the liquid glass with natural paint, could applied to the wooden surfaces by spraying or brushing after applied the natural colorant it is possible to obtain more positive results. Today, where environmental and human health gaining importance, these results cannot be taken away from the idea that natural-based colorants may be an innovative solution as an alternative to synthetics.

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Mehmet Yeniocak*, Suleyman Kahveci
Mugla Sitki Kocman University
Faculty of Technology
Department of Woodworking Industrial Engineering
Mugla, 48000
Turkey
Corresponding author: myeniocak@mu.edu.tr
Phone: +90 252 211 5525