WOOD RESEARCH
63 (3): 2018
443-454

DETERMINATION OF LEACHING FEATURES OF WOOD SURFACES COLORED BY ECO-FRIENDLY RED BEETROOT (*BETA VULGARIS*) EXTRACT

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(Received November 2017)

ABSTRACT

The aim of this study to develop an eco-friendly wood stain and to determine the adsorption and desorption on surfaces. In this context; plant dyestuff was extracted from the red beetroot by using ultrasonic assisted method and applied to wood blocks of Turkish oriental beech, Scots pine, oak, and walnut with immersion (classic) and ultrasonic-assisted immersion methods. As mordants, ferrous sulphate, aluminum sulphate, copper sulphate, and vinegar were chosen. In the study, the effect of such parameters as the medium pH (3, 7 and 9), temperature (22°C and 40°C), velocity of agitation (10 and 30 rpm) in leaching was investigated. As a result of experiments; red beetroot extracts performed good desorption, vinegar and copper sulphate were reduced the best desorption on surfaces. Ultrasonic-assisted method was not affect the leaching performance positively, but general leaching results showed that red beetroot can be used for wood surface stain and they can be alternative to chemical dyes.

KEY WORDS: Natural dyes, red beetroot, leaching.

INTRODUCTION

Wood materials need to preservation and coloring by chemicals against destructive factors. But unfortunately these chemicals contain harmful substances that threaten the environment and human health. Recently international awareness of environment, ecology and pollution control created an upsurge on the interest of people to use more environmentally products. Natural dyes

derived from flora and fauna compared to synthetic are believed to be safe because of their non-toxic, non-carcinogenic and biodegradable nature (Mirjalili et al. 2011).

Though natural dyes have been used for coloring for centuries, there is a lack of scientific research from many aspects. In recent years, importance attached to natural dyes as environmental friendly materials has increased. Although synthetic dyes are cost-effective, natural dyes can compete with them due to variety of their sources (Dixit and Jahan 2005, Colak 2016). For this reason, the importance of the protection of wood material by natural sources is gaining importance day by day. Recent studies present that natural colorants extracted from plants could use to color and protect the wood material against harmful threats (Ozen et al. 2014a, 2014b, Goktas et al. 2008, Colak 2016).

Red beetroot (*Beta vulgaris*), a native of the coasts of Mediterranean, is extensively cultivated in Europe, America and many parts of India (Chopra et al. 1956, Subramoniam and Pushpangadan 1999). Betanin, obtained from the roots, is used industrially as red food colorants, e.g. to improve the color and flavor of tomato paste, sauces, desserts, jams and jellies, ice cream, sweets, and breakfast cereals (Grubben and Denton, 2004). Beetroot dye may also be used in ink. Within older bulbs of beetroot, the color is a deep crimson, and the flesh is much softer.

Nowadays red beetroot was mentioned as a natural dye source in various scientific researches. Goncalves et al. (2011) investigated the beetroot extract as a colorant for cream cheese, they reported that beetroot extracts might be a potential alternative dye for food. Sivakumar et al. (2009), has been studied on the use of power ultrasonic to improve the extraction of beetroot dye and application to the substrates such as leather and they reported that the beetroot is suitable for dying leather. Yeniocak et al. (2015) studied the beetroot as a natural colorant source for wood surfaces; they reported beetroot extracts may be used alternative to synthetic dyes as an upper surface dyestuff for indoor application and toys.

In this study we have focused on the coloring wood material by red beetroot extract and mordant mixes to determine their leaching performance. Another aim is to utilize the potential of natural sources as a substitute colorant for synthetic dyes.

MATERIAL AND METHODS

Wood materials

As wood material, Scots pine (*Pinus sylvestris*), oriental beech (*Fagus orientalis*), oak (*Quercus petraea*) and walnut (*Juglans regia*) woods were chosen. The samples prepared for leaching tests with 19×19×19 mm and were kept under suitable temperature (20 ± 2°C) and suitable moisture (moisture of ±12% and relative moisture content of ±65%) conditions until they became air-dried.

Plant material and Mordant agents

Red beetroot bought from the Mugla province (Turkey). Mordant agents ferrous sulphate ($Fe_2(SO_4)37.H_2O$), aluminum sulphate ($Al_2(SO_4)318.H_2O$) and copper sulphate ($CuSO_25.H_2O$) were provided from Kimetsan Co. and grape vinegar was purchased from Fersan Co.

Preparation of dyestuff

A weighed amount of dry plant material was extracted with distilled water in a ultrasonic bath (Elmasonic X-tra 150 H). In the standard procedure the mass ratio of plant material to the volume of liquid was 1:20; extraction was performed for approximately. 180 min. at 45°C and 180 W sonic power in a stainless ultrasonic bath. Due to the rather high liquor ratio some manual stirring was sufficient to distribute the plant material in the liquid during the extraction period.

Aqueous solutions were mordanted by adding ferrous sulphate ($Fe_2(SO_4)_37.H_2O$) 3%, aluminum sulphate ($KAl_2(SO_4)_318.H_2O$) 5%, copper sulphate ($CuSO_25.H_2O$) 5%, and grape vinegar 10% in order to stabilize the color of extracted dyes, to ensure it to hang on to the applied material (to increase retention amount), and to create color options.

Dyeing test samples

The air-dried wood specimens were placed into ultrasonic bath container according to their intended treatments. Treatment procedures are given in Tab. 1.

Tab. 1: Treatment procedures.

Dye	Treatment method	Sonic power (W)	Temperature (°C)	Time (min)
Natural	Control (immersion)	---	45	60
	Ultrasonic-assisted immersion	300	45	60

In the treatment two different methods (immersion and ultrasonic-assisted immersion) of dyeing were used. Any extra solution left on the specimens was removed with a clean cloth. Specimens were then left to dry at 20±3°C in a vertical position.

Leaching test procedure

Maximum wave length of beetroot extract and mordant mixes were determined by using UV spectrophotometer (Libra/Biochrom brand) for to use as reference point for absorbance. Two wood samples from each group were placed into Erlenmeyer flask in 250 ml distilled water. Erlenmeyer flasks placed into shaking water bath(JSR/JSSP-30 T brand) during 120 minutes. In 5, 15, 30, 45, 60, 75, 90, 120 minutes some water was taken from Erlenmeyer to get amount of dye was absorbed into the water and measured by using UV spectrophotometer with reference to the maximum wave length of each dye. Literature indicated some 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, 1995b; 1998, Breslin and Adler-Ivanbrook, 1998, Hingston et al. 2000, 2002). Leaching experimental parameters are designed by taking into account the effective factors mentioned in the literature. According to that; leach water was held at different temperature (22°C, 40°C), pH (3, 5, 7) and velocity of agitation (10 rpm and 30 rpm) to compare effect on leaching rate.

RESULTS AND DISCUSSION

UV spectrophotometer was used to determine maximum wavelength of red beetroot (*Beta vulgaris*) extract and mordanting concentrations (Tab. 2). These parameters were used as a reference point to find adsorption of each colorant.

Tab. 2: Maximum wavelength of dye.

Type of dye	Max. wavelength (nm)
Control (100% *Beta vulgaris*)	362
Beta vulgaris+ Ferrous sulphate	380
Beta vulgaris+ Aluminum sulphate	364
Beta vulgaris+ Copper sulphate	810
Beta vulgaris+ Vinegar	492

Leaching data at pH:3

Results of leaching test under conditions pH: 3, 22°C temperature and 10 rpm velocity of agitation given in Tab. 3.

Tab. 3: Leaching data (abs) of beetroot (Beta vulgaris) at pH: 3.

Wood type	Leaching time (min)	Control		*Beta vulgaris* + ferrous sulphate		*Beta vulgaris* + Alum		*Beta vulgaris* + copper sulphate		*Beta vulgaris* + vinegar	
		U	C	U	C	U	C	U	C	U	C
Scots pine	5	0.012	0.018	0.025	0.022	0.018	0.015	0.007	0.003	0.003	0.005
	15	0.022	0.031	0.030	0.030	0.021	0.017	0.011	0.007	0.007	0.006
	30	0.028	0.037	0.041	0.037	0.024	0.021	0.010	0.008	0.010	0.007
	60	0.031	0.042	0.054	0.059	0.029	0.027	0.011	0.010	0.011	0.009
	75	0.034	0.047	0.063	0.063	0.034	0.031	0.014	0.013	0.014	0.010
	90	0.039	0.052	0.072	0.065	0.038	0.038	0.014	0.018	0.016	0.012
	120	0.056	0.059	0.080	0.080	0.044	0.041	0.015	0.024	0.018	0.014
Beech	5	0.014	0.009	0.023	0.025	0.011	0.024	0.007	0.006	0.003	0.005
	15	0.016	0.013	0.027	0.032	0.023	0.026	0.013	0.008	0.005	0.006
	30	0.018	0.019	0.047	0.037	0.026	0.029	0.015	0.009	0.007	0.008
	60	0.023	0.021	0.049	0.040	0.028	0.032	0.017	0.010	0.009	0.010
	75	0.025	0.027	0.055	0.047	0.033	0.038	0.021	0.012	0.010	0.014
	90	0.030	0.030	0.058	0.053	0.035	0.043	0.027	0.013	0.013	0.018
	120	0.036	0.034	0.061	0.055	0.039	0.049	0.034	0.016	0.018	0.022
Walnut	5	0.027	0.032	0.026	0.023	0.031	0.026	0.009	0.004	0.003	0.005
	15	0.023	0.039	0.032	0.034	0.028	0.041	0.012	0.006	0.003	0.007
	30	0.035	0.046	0.037	0.037	0.036	0.055	0.013	0.011	0.009	0.006
	60	0.051	0.062	0.049	0.057	0.052	0.074	0.014	0.010	0.007	0.006
	75	0.050	0.071	0.052	0.062	0.058	0.083	0.017	0.014	0.009	0.008
	90	0.060	0.076	0.063	0.061	0.059	0.091	0.016	0.010	0.006	0.008
	120	0.075	0.088	0.061	0.071	0.068	0.110	0.017	0.011	0.010	0.009
Oak	5	0.020	0.033	0.019	0.013	0.014	0.026	0.007	0.007	0.003	0.007
	15	0.039	0.043	0.025	0.015	0.019	0.034	0.008	0.009	0.005	0.009
	30	0.048	0.051	0.034	0.019	0.022	0.037	0.010	0.010	0.007	0.011
	60	0.052	0.068	0.048	0.020	0.025	0.038	0.012	0.011	0.009	0.017
	75	0.054	0.071	0.049	0.026	0.030	0.041	0.019	0.012	0.011	0.019
	90	0.059	0.081	0.051	0.031	0.032	0.042	0.022	0.013	0.013	0.021
	120	0.081	0.086	0.071	0.036	0.035	0.052	0.027	0.015	0.017	0.024

U: Ultrasonic method, C: Classic method

According to the leaching test results; at Scotch pine samples minimum leaching value was measured on vinegar added group applied by classic application 0.014 abs, maximum leaching performance measured on group iron sulphate added in both application method 0.080 abs. During control group measured for ultrasonic-assisted application 0.056 abs and for classic application 0.059 abs.

For oriental beech samples maximum leaching value was measured on group mordanted with iron sulphate in both ultrasonic and classic method respectively 0.061 abs and 0.065 abs.

Minimum leach measured on group mordanted with copper sulphate, applied by classic method 0.016 abs while control group measured 0.036 abs on ultrasonic method and 0.034 abs on classic application.

On samples walnut maximum leaching was measured on group mordanted with aluminum sulphate applied by classic method 0.110 abs. Vinegar added group showed the best leaching performance applied bu classic method 0.009 abs throughout control group measured 0.075 abs on ultrasonic application and 0.088 abs on classic application.

For Oak samples maximum leaching measured on group mordanted with iron sulphate applied by ultrasonic-assisted method 0.071 abs. Minimum one measured on group mordanted with copper sulphate 0.015 abs applied by classic method. While control group performed on ultrasonic application 0.081 abs and classic application 0.086 abs.

Leaching data at pH:7

Results of leaching test under condition pH: 7, 22°C temperature and 10 rpm velocity of agitation given in Tab. 4.

Tab. 4: Leaching data (abs) of red beetroot (Beta vulgaris) at pH: 7.

Wood type	Leaching time (min)	Control		*Beta vulgaris* + ferrous sulphate		*Beta vulgaris* + Alum		*Beta vulgaris* + copper sulphate		*Beta vulgaris* + vinegar	
		U	C	U	C	U	C	U	C	U	C
Scots pine	5	0.017	0.014	0.026	0.024	0.007	0.011	0.006	0.004	0.002	0.002
	15	0.019	0.016	0.028	0.030	0.010	0.014	0.010	0.006	0.003	0.003
	30	0.020	0.018	0.030	0.036	0.012	0.016	0.011	0.008	0.004	0.004
	60	0.025	0.021	0.034	0.041	0.015	0.019	0.014	0.009	0.007	0.006
	75	0.029	0.024	0.037	0.044	0.018	0.021	0.016	0.010	0.008	0.008
	90	0.032	0.027	0.039	0.047	0.020	0.024	0.017	0.011	0.009	0.009
	120	0.036	0.031	0.041	0.049	0.024	0.029	0.019	0.013	0.011	0.012
Beech	5	0.008	0.011	0.020	0.022	0.002	0.005	0.006	0.005	0.002	0.002
	15	0.012	0.016	0.028	0.027	0.005	0.007	0.008	0.008	0.003	0.004
	30	0.014	0.018	0.034	0.032	0.008	0.009	0.01	0.010	0.005	0.006
	60	0.019	0.023	0.040	0.038	0.011	0.012	0.014	0.013	0.007	0.009
	75	0.022	0.025	0.043	0.039	0.013	0.014	0.017	0.015	0.009	0.011
	90	0.024	0.026	0.045	0.040	0.015	0.015	0.019	0.017	0.011	0.013
	120	0.026	0.029	0.047	0.042	0.017	0.018	0.021	0.019	0.014	0.015
Walnut	5	0.016	0.028	0.015	0.009	0.006	0.006	0.006	0.005	0.001	0.001
	15	0.021	0.034	0.018	0.015	0.016	0.012	0.008	0.007	0.004	0.004
	30	0.026	0.041	0.025	0.020	0.020	0.020	0.012	0.008	0.007	0.008
	60	0.031	0.049	0.029	0.024	0.026	0.024	0.014	0.011	0.011	0.012
	75	0.037	0.055	0.033	0.028	0.029	0.028	0.015	0.013	0.014	0.015
	90	0.042	0.062	0.037	0.034	0.032	0.031	0.016	0.015	0.017	0.018
	120	0.048	0.071	0.041	0.039	0.038	0.036	0.018	0.018	0.022	0.022

Oak	5	0.018	0.023	0.021	0.016	0.011	0.007	0.006	0.006	0.001	0.004
	15	0.026	0.031	0.024	0.019	0.013	0.012	0.007	0.009	0.003	0.006
	30	0.031	0.039	0.025	0.023	0.014	0.017	0.009	0.011	0.006	0.009
	60	0.038	0.047	0.027	0.027	0.016	0.021	0.011	0.013	0.009	0.013
	75	0.044	0.053	0.029	0.029	0.018	0.024	0.013	0.015	0.011	0.016
	90	0.051	0.059	0.030	0.031	0.021	0.027	0.014	0.017	0.013	0.018
	120	0.064	0.071	0.032	0.033	0.025	0.030	0.017	0.020	0.015	0.021

U: Ultrasonic method, C: Classic method

According to leaching test results; in all wood species maximum leaching measured in group mordanted with iron sulphate, for Scotch pine 0.049 abs, for oak 0.033 abs applied by classic method and for beech 0.047 abs and for walnut 0.041 abs. Moreover, minimum leaching results performed for all wood species in group mordanted with vinegar and applied by ultrasonic-assisted method (except walnut), for Scots pine 0.011 abs, for beech 0.014 abs, for oak 0.015 abs this value measured for walnut 0.018 abs in group copper sulphate in both application method.

Leaching performance values of control groups was measured for Scots pine, beech, walnut and oak species respectively in ultrasonic-assisted method 0.036 abs, 0.026 abs, 0.048 and 0.071 abs, in classic method respectively 0.031 abs, 0.029 abs and for walnut and oak 0.071 abs.

Leaching data at pH: 9

Results of leaching test under condition pH: 9, 22°C temperature and 10 rpm velocity of agitation given in Tab. 5.

Tab. 5: Leaching data(abs) of red beetroot (Beta vulgaris) at pH: 9.

Wood type	Leaching time (min)	Control		*Beta vulgaris* + Ferrous Sulphate		*Beta vulgaris* + Alum		*Beta vulgaris* + Copper sulphate		*Beta vulgaris* + Vinegar	
		U	C	U	C	U	C	U	C	U	C
Scots Pine	5	0.023	0.025	0.028	0.034	0.017	0.023	0.007	0.006	0.002	0.002
	15	0.029	0.029	0.032	0.042	0.027	0.033	0.010	0.010	0.004	0.006
	30	0.027	0.033	0.034	0.051	0.030	0.041	0.018	0.017	0.008	0.008
	60	0.031	0.038	0.036	0.057	0.037	0.049	0.021	0.022	0.010	0.012
	75	0.033	0.042	0.041	0.063	0.042	0.051	0.024	0.026	0.016	0.021
	90	0.035	0.047	0.048	0.071	0.045	0.057	0.027	0.033	0.022	0.029
	120	0.047	0.052	0.054	0.076	0.049	0.061	0.030	0.039	0.035	0.034
Beech	5	0.014	0.031	0.041	0.048	0.012	0.021	0.005	0.006	0.003	0.003
	15	0.016	0.033	0.045	0.053	0.019	0.029	0.008	0.008	0.004	0.006
	30	0.019	0.039	0.053	0.056	0.020	0.035	0.010	0.010	0.005	0.008
	60	0.024	0.042	0.064	0.066	0.023	0.041	0.012	0.012	0.007	0.010
	75	0.026	0.045	0.068	0.075	0.025	0.049	0.014	0.014	0.009	0.013
	90	0.032	0.049	0.073	0.079	0.028	0.055	0.017	0.016	0.011	0.015
	120	0.043	0.057	0.081	0.084	0.033	0.062	0.020	0.019	0.015	0.019

Walnut	5	0.016	0.027	0.042	0.028	0.020	0.030	0.011	0.006	0.001	0.002
	15	0.026	0.040	0.044	0.036	0.033	0.036	0.012	0.009	0.003	0.004
	30	0.032	0.060	0.054	0.052	0.048	0.043	0.015	0.010	0.004	0.006
	60	0.048	0.064	0.062	0.077	0.056	0.059	0.018	0.013	0.008	0.008
	75	0.055	0.077	0.076	0.081	0.060	0.064	0.022	0.017	0.010	0.010
	90	0.058	0.082	0.079	0.092	0.065	0.073	0.027	0.021	0.011	0.011
	120	0.070	0.099	0.082	0.108	0.072	0.078	0.038	0.033	0.016	0.018
Oak	5	0.038	0.046	0.052	0.051	0.028	0.023	0.007	0.006	0.003	0.002
	15	0.041	0.052	0.065	0.063	0.032	0.025	0.008	0.008	0.005	0.003
	30	0.052	0.055	0.068	0.065	0.038	0.028	0.010	0.009	0.007	0.005
	60	0.055	0.059	0.071	0.068	0.041	0.034	0.012	0.010	0.009	0.006
	75	0.062	0.067	0.079	0.076	0.044	0.038	0.013	0.011	0.010	0.008
	90	0.067	0.075	0.081	0.087	0.051	0.042	0.014	0.012	0.012	0.009
	120	0.072	0.079	0.087	0.093	0.057	0.048	0.017	0.015	0.015	0.011

U: Ultrasonic method, C: Classic method

According to leaching test results; in all wood species maximum leaching measured in group mordanted with iron sulphate applied by classic method, for Scotch pine 0.076 abs, for beech 0.084 abs for walnut 0.108 abs and for oak 0.093 abs. On the other side minimum leaching result performed for all wood species in group mordanted with vinegar, for Scots pine 0.030 abs, for beech 0.015 abs, for walnut 0.016 abs applied by ultrasonic-assisted method and for oak 0.015 abs applied by classic method. While control group measured on application ultrasonic-assisted method on Scots pine, beech, walnut and oak respectively 0.047 abs, 0.043 abs, 0.070 abs and 0.072 abs, on classic application those values measured respectively 0.052 abs, 0.057 abs, 0.099 abs and 0.079 abs.

Leaching data at 40°C temperature

Results of leaching test under condition pH: 7, 40°C temperature and 10 rpm velocity of agitation given in Tab. 6.

Tab. 6: Leaching data (abs) of red beetroot (Beta vulgaris) at 40°C temperature.

Wood type	Leaching time (min)	Control		*Beta vulgaris* + ferrous sulphate		*Beta vulgaris* + alum		*Beta vulgaris* + copper sulphate		*Beta vulgaris* + vinegar	
		U	C	U	C	U	C	U	C	U	C
Scots pine	5	0.016	0.015	0.049	0.038	0.017	0.016	0.008	0.009	0.007	0.003
	15	0.025	0.028	0.055	0.046	0.025	0.034	0.014	0 .016	0.006	0.008
	30	0.028	0.039	0.066	0.048	0.029	0.032	0.018	0.019	0.008	0.013
	60	0.033	0.046	0.078	0.052	0.035	0.039	0.021	0.022	0.011	0.015
	75	0.038	0.058	0.082	0.058	0.039	0.043	0.025	0.025	0.014	0.017
	90	0.048	0.079	0.088	0.062	0.042	0.052	0.029	0.028	0.019	0.019
	120	0.055	0.087	0.097	0.069	0.059	0.059	0.035	0.031	0.021	0.022

Beech	5	0.032	0.015	0.028	0.022	0.017	0.016	0.009	0.007	0.008	0.009
	15	0.039	0.018	0.032	0.026	0.020	0.023	0.014	0.009	0.010	0.011
	30	0.044	0.027	0.034	0.032	0.023	0.032	0.017	0.011	0.013	0.013
	60	0.054	0.031	0.039	0.036	0.029	0.035	0.021	0.014	0.015	0.017
	75	0.059	0.041	0.046	0.042	0.031	0.039	0.024	0.017	0.017	0.019
	90	0.068	0.044	0.049	0.047	0.036	0.046	0.027	0.019	0.019	0.021
	120	0.074	0.047	0.053	0.052	0.042	0.049	0.032	0.025	0.024	0.025
Walnut	5	0.023	0.043	0.018	0.033	0.032	0.028	0.008	0.009	0.005	0.008
	15	0.043	0.048	0.026	0.036	0.033	0.039	0.009	0.011	0.008	0.009
	30	0.047	0.070	0.042	0.039	0.047	0.044	0.011	0.013	0.011	0.011
	60	0.068	0.100	0.047	0.045	0.056	0.062	0.013	0.017	0.014	0.016
	75	0.083	0.109	0.057	0.056	0.065	0.078	0.016	0.019	0.018	0.014
	90	0.110	0.121	0.068	0.067	0.072	0.080	0.019	0.023	0.021	0.018
	120	0.141	0.145	0.080	0.075	0.086	0.097	0.025	0.029	0.028	0.023
Oak	5	0.028	0.058	0.025	0.018	0.030	0.024	0.009	0.008	0.006	0.005
	15	0.040	0.061	0.021	0.025	0.035	0.038	0.011	0.012	0.009	0.008
	30	0.051	0.068	0.039	0.028	0.038	0.041	0.014	0.018	0.011	0.012
	60	0.065	0.092	0.045	0.034	0.041	0.044	0.016	0.021	0.015	0.015
	75	0.067	0.104	0.049	0.042	0.045	0.054	0.021	0.024	0.019	0.019
	90	0.072	0.121	0.051	0.047	0.052	0.057	0.025	0.032	0.022	0.024
	120	0.094	0.130	0.064	0.056	0.058	0.062	0.034	0.039	0.031	0.029

U: Ultrasonic method, C: Classic method.

According to leaching test results; in all wood species (except walnut) maximum leaching measured in group mordanted with iron sulphate applied by ultrasonic-assisted method, for Scotch pine 0.097 abs, for beech 0.053 abs for oak 0.064 abs and for walnut that value measured in group aluminum sulphate applied by classic method 0.097 abs. On the other side minimum leaching result performed for all wood species in group mordanted with vinegar, for Scots pine 0.021 abs, for beech 0.024 abs, applied by ultrasonic-assisted method for walnut 0.023 abs and for oak 0.029 abs in classic application. While control group measured on application ultrasonic-assisted method on Scots pine, beech, walnut and oak respectively 0.055 abs, 0.0074 abs, 0.141 abs and 0.094 abs, on classic application those values measured respectively 0.087 abs, 0.047 abs, 0.145 abs and 0.130 abs.

Leaching data of velocity of agitation at 30 rp

Results of leaching test under condition pH: 7, 22°C temperature and 30 rpm velocity of agitation given in Tab. 7.

According to leaching test results; in all wood species maximum leaching measured in group mordanted with iron sulphate, for Scotch pine 0.084 abs, for beech 0.062 abs and for oak 0.073 abs applied by ultrasonic-assisted method and for walnut 0.072 abs. Moreover, minimum leaching results performed for all wood species in group mordanted with vinegar for Scots pine 0.018 abs, for walnut 0.19 abs applied by classic method, this value measured for beech 0.024 abs and for oak 0.018 abs applied by ultrasonic-assisted method. Leaching performance values of control groups was measured for Scots pine, beech, walnut and oak species respectively in ultrasonic-assisted method 0.054 abs, 0.036 abs, 0.073 and 0.080 abs, in classic method respectively 0.057 abs, 0.037 abs, 0.089 and 0.080 abs.

Tab. 7: Leaching data (abs) of velocity of agitation at 30 rpm.

Wood type	Leaching time (min)	Control		*Beta vulgaris* + ferrous sulphate		*Beta vulgaris* + alum		*Beta vulgaris* + copper sulphate		Beta vulgaris + vinegar	
		U	C	U	C	U	C	U	C	U	C
Scots pine	5	0.014	0.019	0.025	0.024	0.019	0.016	0.009	0.004	0.005	0.006
	15	0.024	0.030	0.032	0.035	0.022	0.019	0.010	0.009	0.009	0.008
	30	0.029	0.035	0.040	0.039	0.025	0.022	0.012	0.011	0.011	0.010
	60	0.032	0.041	0.052	0.057	0.030	0.029	0.014	0.014	0.013	0.012
	75	0.036	0.048	0.061	0.060	0.033	0.033	0.016	0.016	0.016	0.014
	90	0.038	0.051	0.070	0.071	0.039	0.035	0.017	0.019	0.018	0.015
	120	0.054	0.057	0.084	0.082	0.041	0.040	0.019	0.022	0.020	0.018
Beech	5	0.015	0.010	0.022	0.027	0.013	0.027	0.009	0.009	0.005	0.006
	15	0.017	0.013	0.025	0.033	0.025	0.029	0.014	0.011	0.008	0.009
	30	0.019	0.018	0.044	0.037	0.028	0.031	0.016	0.015	0.009	0.011
	60	0.024	0.020	0.049	0.042	0.029	0.035	0.019	0.018	0.010	0.013
	75	0.028	0.025	0.053	0.045	0.033	0.039	0.022	0.021	0.013	0.016
	90	0.031	0.033	0.059	0.052	0.037	0.044	0.029	0.027	0.018	0.020
	120	0.036	0.037	0.062	0.059	0.042	0.049	0.033	0.035	0.024	0.029
Walnut	5	0.027	0.031	0.029	0.027	0.032	0.029	0.010	0.005	0.006	0.008
	15	0.028	0.039	0.031	0.035	0.029	0.034	0.013	0.008	0.009	0.009
	30	0.035	0.045	0.038	0.039	0.039	0.051	0.015	0.011	0.011	0.011
	60	0.050	0.062	0.047	0.055	0.052	0.070	0.016	0.014	0.016	0.012
	75	0.054	0.073	0.053	0.066	0.059	0.082	0.019	0.016	0.019	0.014
	90	0.065	0.078	0.060	0.069	0.061	0.093	0.021	0.019	0.022	0.016
	120	0.073	0.089	0.064	0.072	0.069	0.112	0.026	0.021	0.026	0.019
Oak	5	0.031	0.032	0.021	0.014	0.015	0.028	0.009	0.009	0.005	0.008
	15	0.038	0.040	0.025	0.017	0.019	0.034	0.010	0.011	0.007	0.009
	30	0.046	0.050	0.033	0.021	0.022	0.039	0.013	0.013	0.009	0.011
	60	0.051	0.062	0.047	0.025	0.025	0.042	0.015	0.016	0.010	0.017
	75	0.052	0.070	0.049	0.029	0.032	0.045	0.021	0.019	0.013	0.019
	90	0.059	0.080	0.052	0.033	0.035	0.047	0.023	0.021	0.015	0.022
	120	0.080	0.080	0.073	0.037	0.039	0.052	0.027	0.024	0.018	0.025

U: Ultrasonic method, C: Classic method

The effect of such parameters pH (3, 7 and 9), temperature (22°C and 40°C), and velocity of agitation (10 and 30 rpm) was investigated. Minimum leaching was performed in all wood types with pH:7, maximum leaching observed in Scots pine and oak wood species at 40°C, in beech wood at pH:9 and in walnut measured close values at 40°C and pH: 9.This difference is thought to depend on the amount of extractive substances contained in the wood species. Experimental results have showed that acidic and alkali environment in addition the increasing of temperature and increase in velocity of agitation directly increased the leaching, these results are supported by studies in the literature (Dahlgren 1975, Warner and Solomon 1990, Cooper 1991, 1994, Van Eetvelde et al. 1995a; 1995b; 1998, Breslin and Adler-Ivanbrook 1998, Hingston et al. 2000; 2002).

CONCLUSIONS

Mordant agents were affected the leaching performance in the positive direction except iron sulphate. Especially utilizing vinegar and copper sulphate were decreased adsorption compared to control group approximately in rate 50% - 70%. The use of mordants is to increase the binding of natural dye to functional groups in the wood material. According to these results, it was observed that mordants in general increase the binding, especially in the copper sulphate and vinegar groups. Iron sulphate, aluminum sulphate and copper sulphate are metal salts the most widely used mordants in the natural paint sector. These salts are not fully dissolved in water and remain in particles that are too large to pass through the porous structure of the wood material, which is an important parameter in the surface processes. For this reason, the mordant salts are physically trapped on the surface of the wood material and can easily be separated from the surface during leaching. Nevertheless, they were improved leaching performance compared to the control group. In addition, due to the structure of iron sulphate, when it comes into contact with water, it is corroded to produce a darker color and that resultedto change the color of the leaching water more than the others, thus it has been observed that the maximum washing is measured in this group. We used ultrasonic-assisted immersion method for the application of natural colorant to wood materials to have increased the bonding of natural paint to wood surfaces, compared to the classical immersion method. Unfortunately, results not meet our expectations on using ultrasonic-assisted immersion.

In general, the leach values were measured at small ratios, and these results boost edusability natural colorant instead of synthetic and support previous studies in terms of leaching addition to protection against fungus (Ozen et al 2014b), combustion retardation (Yeniocak et al. 2016), color stability (Goktas et al. 2008, Yeniocak et al. 2015). As a result of this experiment, red beetroot extracts performed well desorption on surfaces. It was concluded that red beetroot can be used for wood surface stain and they can be alternative to chemical dyes.

ACKNOWLEDGEMENT

This manuscript is prepared from the outcome of a project which supported by TÜBİTAK TOVAG (1001). Project number: 110O141. The outcome also oral presented as full text in IIndInternational Furniture Congress 13-15 October 2016 held in Mugla/Turkey.

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