10th International Research/Expert Conference
"Trends in the Development of Machinery and Associated Technology"
TMT 2006, Barcelona-Lloret de Mar, Spain, 11-15 September, 2006

A STUDY ON THE COLOUR CHANGES AND EVOLUTION OF DEGRADATION PHENOMENA OF BEECH WOOD IN OUTDOOR APPLICATIONS

Maria Cristina Timar

Sorin Zamfira

Loredana Ionescu
"Transilvania" University of Braşov,
Department of Wood Technology
29 Eroilor Street, RO- 500036 Braşov 1
Romania

Adrian Dimitriu
"Transilvania" University of Braşov,
Department of Precision Mechanics and Mechatronics
29 Eroilor Street, RO- 500036 Braşov 1
Romania

ABSTRACT

The present paper continues a series of papers dealing with the application of colour measurement techniques in diverse areas of wood technology. Beech wood samples treated by short time immersion with aqueous solutions of copper sulphate, boric acid, borax and potassium dichromate, as individual compounds or in diverse combinations and further conditioned were examined, A part of control and treated samples were further protected with a paraffin emulsion in order to decrease water absorption in exterior conditions. Control and treated samples were exposed to natural light indoors and to natural light and climatic factors outdoors. Reference samples were kept in dark conditions. The exposed samples were periodically investigated by direct observation, were scanned and colour measurements were performed using a Specord M40 apparatus. Based on the colour coordinates in the CIE Lab system, colour differences were calculated between exposed and reference samples for the controls and treated samples. These calculated values were compared with the results of the direct examination of samples in order to conclude on the method applicability and limits and on the influence of the treating chemicals on the weathering resistance of beech wood.

Keywords: colour measurement, beech wood, copper, boron, chromium compounds

1. INTRODUCTION

Inorganic compounds containing copper, boron and chromium are quite frequently used in wood preservation technologies in order to improve its biological resistance to fungal and insects attack. However, these products may affect some other properties of wood, including its natural colour and resistance to light in indoors conditions and to weathering in outdoors exposure.

The present paper continues a series of papers dealing with the application of colour measurement techniques in diverse areas of wood technology in order to evaluate the opportunities for their improvement and/or modernisation [1,2,3]. The present paper resumes investigations on the influence of copper sulphate, boric acid, borax and potassium dichromate, as individual compounds or in diverse combinations, on the light resistance and weathering resistance of beech wood, presenting the evolution in time of colour changes in indoors and outdoors conditions.

2. MATERIALS AND METHODS

Beech wood (*Fagus sylvatica*) were treated by short time immersion (15 min at 20°C) with aqueous solutions of copper, boron and chromium compounds and further conditioned for 14 days at 20-23°C and 50-55 % RH, as previously presented [3]. Control samples (C) were also prepared by similarly treating beech samples with distilled water. The treating variants and codes are presented in Table 1. A part of control and treated samples were further protected with a paraffin emulsion coat (further coded wax in this paper) in order to decrease water absorption in exterior conditions.

Table 1 Chemicals used for the treatment of Beech wood samples

Chemicals used for wood treatment	Formulas	Code Colour of solution	Treatment code	Conc. [%]
Distilled water	H_2O	-	C	-
Cooper sulphate	$CuSO_4*5H_2O$	S1 Blue	V1	5
Borax + Boric acid (81 / 19 weight ratio)	$Na_2B_4O_7*10H_2O$ + H_3BO_3	S2 Colourless	V2	5
Potassium dichromate	$K_2Cr_2O_7$	S3 Orange	V3	5
Cooper sulphate + Potassium dichromate (55 / 45 weight ratio)	$CuSO_4*5H_2O$ + $K_2Cr_2O_7$	S4 Greenish brown	V4	5
Borax + Boric acid + Potassium dichromate (44.55 /10.45 / 45 weight ratio)	$Na_2B_4O_7*710H_2O$ + H_3BO_3 +$K_2Cr_2O_7$	S5 Yellow-orange	V5	5

Control and treated samples were exposed to natural light indoors and to natural light and climatic factors outdoors. Reference samples were kept in dark conditions. The exposed samples were periodically investigated by direct observation, were scanned and colour measurements were performed using a Specord M40 apparatus. Based on the colour coordinates in the CIE Lab system, colour differences (formula1) were calculated between exposed and reference samples. These calculated values were compared with the results of the direct examination of the samples. The present paper is specifically referring to the evaluation after 21 months exposure, presenting the resulted data in comparison to those previously determined after a shorter exposure period of 9 months.

$$\Delta E = \sqrt{(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2} \quad (1)$$

3. RESEARCH RESULTS

The results of colour measurements and of colour differences calculation are summarised in Table 2 for all the samples: unmodified, controls and treated as reference or exposed samples. These results were further processed in the graphs in Figure 1, Figure 2.

As expectable, the global colour changes after 21 months exposure were higher in outdoors conditions than in indoors conditions (Figure 1). All the weathered samples got a characteristic dark grey colour, mostly due to the concerted action of UV light and rainwater. In contrast, the indoor samples suffered colour changes characterised as darkening of the original colour or colour change to yellow-brown.

Black spots and other discolouration phenomena (graded from 0 to 3 as a function to their existence and intensity) were present on the weathered samples, but these could be more correctly evaluated on the back of the samples.

The supplementary wax treatment did not influence significantly the weathering resistance and, accordingly, the colour differences calculated for outdoors samples, but increased significantly the biological resistance of exposed samples (Figure 3).

The colour changes were accentuated in comparison to those observed after 9 months exposure for both the indoor and outdoor samples. However, the calculated colour differences evolved differently

depending on the type of treatment (Figure 2). This is because they cumulate real colour changes (x, y and a, b values) with darkening (decrease of L values).

Table 2 Colour coordinates and colour differences

Treatment /Sample code	Exposure conditions	Colour coordinates					Colour differences
		Tri-Chromatic coordinates		CIE Lab coordinates			
		x	y	L	a	b	Exposed/Reference
Unmodified **M**	Reference	0.349	0.359	74.335	3.577	13.710	
	Exterior 21	0.325	0.346	56.408	-0.955	4.840	20.51
	Interior 21	0.376	0.377	70.458	6.445	22.625	10.14
	Exterior wax 21	0.326	0.348	53.327	-1.128	5.185	23.16
Control **C**	Reference	0.358	0.363	70.418	4.825	15.610	
	Exterior 21	0.324	0.345	58.678	-0.917	4.588	17.10
	Interior 21	0.371	0.375	69.325	5.328	20.798	5.33
	Exterior wax 21	0.323	0.346	53.065	-1.370	4.445	21.54
Treated **V1**	Reference	0.350	0.363	69.008	2.090	14.383	
	Exterior 21	0.325	0.346	60.327	-0.803	5.188	12.97
	Interior 21	0.366	0.373	58.575	3.675	17.185	10.92
	Exterior wax 21	0.324	0.346	54.275	-1.262	4.680	17.96
Treated **V2**	Reference	0.352	0.360	76.217	4.347	14.753	
	Exterior 21	0.326	0.346	60.993	-0.623	5.518	18.49
	Interior 21	0.369	0.373	69.875	5.225	20.128	8.36
	Exterior wax 21	0.324	0.343	58.750	-0.997	4.103	21.14
Treated **V3**	Reference	0.347	0.363	61.615	0.980	17.515	
	Exterior 21	0.326	0.353	51.702	-2.415	6.320	15.33
	Interior 21	0.348	0.367	61.823	0.148	13.775	3.84
	Exterior wax 21	0.328	0.352	49.670	-1.820	6.120	16.74
Treated **V4**	Reference	0.344	0.361	63.363	0.653	11.948	
	Exterior 21	0.331	0.352	54.603	-1.050	6.857	10.27
	Interior 21	0.359	0.373	60.885	1.500	16.627	5.36
	Exterior wax 21	0.327	0.351	49.995	-1.693	5.750	14.92
Treated **V5**	Reference	0.347	0.360	64.480	1.822	12.143	
	Exterior 21	0.322	0.345	52.350	-1.400	4.120	14.90
	Interior 21	0.357	0.370	65.918	2.093	16.457	4.55
	Exterior wax 21	0.329	0.349	57.953	-0.813	6.313	9.14

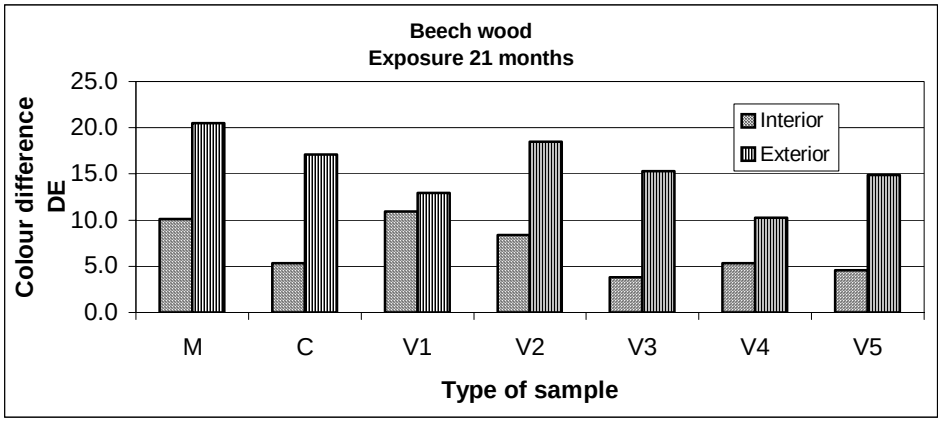
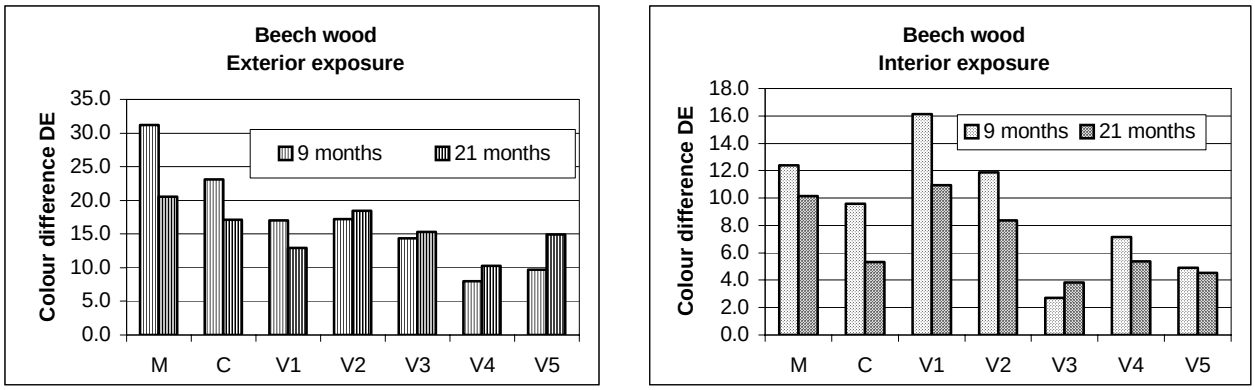


Figure 1 Global colour changes after 21 months indoors and outdoors exposure expressed as colour differences versus the reference samples



A **B**

Figure 2 Evolution of colour changes of beech wood as a function of treatment and exposure conditions

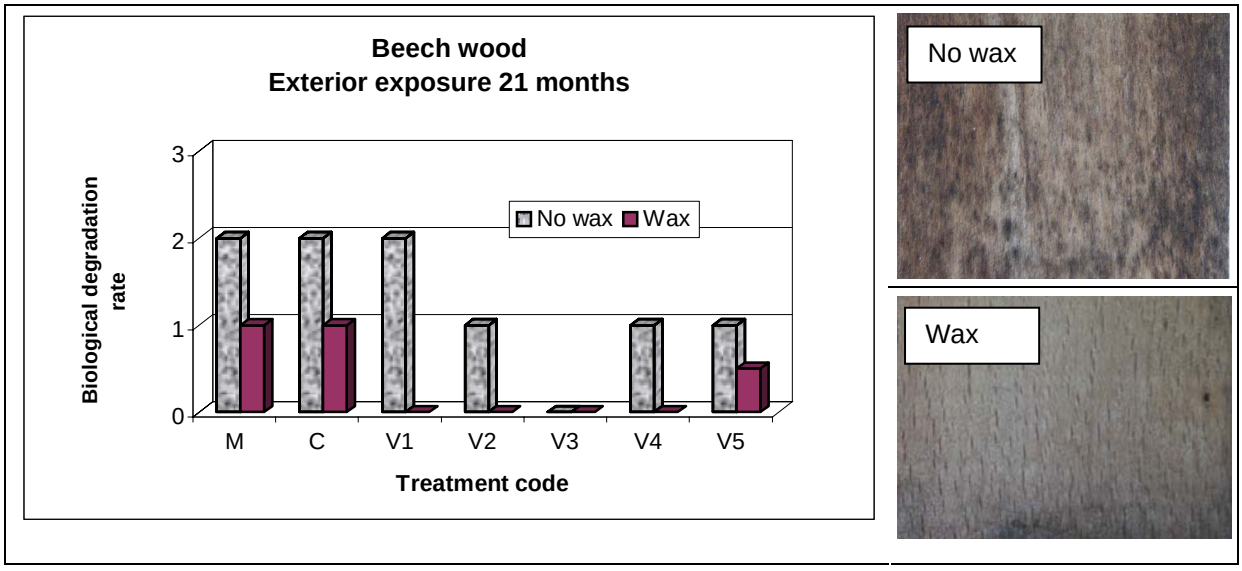


Figure 3 The influence of wax treatment on the biological resistance of beech wood in outdoors conditions: biological degradation rate (left) and aspect details (biotic attack-right top)

4. CONCLUSIONS

The colour measurement technique applied within this research allowed the monitoring of global colour changes brought about by the exposure of beech wood to natural light indoors and to natural light and climatic factors in outdoors conditions, highlighting the influence of different treatments on the light and weathering resistance of beech wood. The evolvement in time of colour/aspect changes can not be, however, fully characterised by a single numerical value, such as the colour difference versus the reference samples. Other aspect changes and degradation phenomena, such as biological discoloration, have to be considered and correspondingly evaluated.

5. REFERENCES

[1] Timar, M.C., Zamfira, S., Beldean, E., Epure, P.: Aspects of wood weathering evaluation using a modern colour measurement technique. Proceedings of TMT 2004 Symposium, Bosnia –Herzegovina, 2004.

[2] Zamfira S., Timar, M.C., Beldean, E: Epure, P.: Colour measurement techniques assisting wood finishing technology, Proceedings of TMT 2004 Symposium, Bosnia-Herzegovina, 2004.

[3] Timar, M.C., Zamfira, S., Bartulov-Ionescu, L., Dimitriu A.: A study of the influence of some inorganic compounds on the colour and weathering resistance of beech wood, Proceedings of TMT 2005 Symposium, Antalya, Turkey, September 2005.