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APPLICATIONS OF THE NORMAL RANGE OF HYDRIC-EQUILIBRIUM VARIATION IN OLD WOOD

Ion SANDU
Prof.univ.dr. - Alexandru Ioan Cuza" University Iasi,
Address: ARHEOINVEST Platform, Blvd. Carol I 11, 700506, Iasi, Romania
Laboratory of Scientific Investigation and Conservation of Cultural Heritage
E-mail: Ion.sandu@uaic.ro

Lăcrămioara Gabriela GHERMAN
Phd. Student - "Alexandru Ioan Cuza" University Iasi - Faculty of Geography; Nature Science
Address: ARHEOINVEST Platform, Blvd. Carol I 11, 700506, Iasi, Romania
Laboratory of Scientific Investigation and Conservation of Cultural Heritage
E-mail: gabrielascutarita@yahoo.com

Raluca Anamaria CRISTACHE
Phd. Student - "Alexandru Ioan Cuza" University Iasi - Faculty of Geography; Nature Science
Address: ARHEOINVEST Platform, Blvd. Carol I 11, 700506, Iasi, Romania
E-mail: raluca_cristache@yahoo.com

Mikiko HAYASHI
National Research Institute for Cultural Propeties, Center for Conservation Science and Restauration Techniques, Tokio, Japan
E-mail: hayashimikiko@gmail.com

Irina Crina Anca SANDU
CSIII.dr. - Requimte e Núcleo do Departamento de Conservação e Restauro, Faculdade de Ciencias e Tecnologia, Universidade Nova de Lisboa
Address: Campus da Caparica, 2829-516 Caparica, Portugal
E-mail: lilly75flower@yahoo.com

Viorica VASILACHE
CS III. - Alexandru Ioan Cuza" University Iasi
Address: ARHEOINVEST Platform, Blvd. Carol I 11, 700506, Iasi, Romania
Laboratory of Scientific Investigation and Conservation of Cultural Heritage
E-mail: viorica_18v@yahoo.com

Abstract:

The paper presents an utilization method for determining the normal range of equilibrium moisture content in establishing the compatibility treatment between old linden wood and organic solutions based on red oil and propolis, which have multiple effects, like ennobling the wood fiber, insecticide, fungicide and hydrophobic. In the experiment were used two groups of samples from linden wood: new wood with the tree age of 75 years and the oldness of 10 years, and old wood with the tree age of 90 years and the oldness of 270 years, the last being with and without xylophagous attack. The samples untreated and treated with red oil and propolis, were subjected to the determination of the normal range of equilibrium moisture content. The data are obtained comparing the normal range of equilibrium moisture content for old untreated linden wood and the treated one with the new untreated and treated linden wood. Those information show that the propolis and red oil treatment do not have a great influence on the characteristics of the correlation between the curves of hydration and dehydration, respective the characteristics of the normal range of equilibrium moisture content.

Key words: *old wood; linden wood; normal range of equilibrium moisture content; dimensional stability; xylofagous attack.*

INTRODUCTION

Old wood from artifacts, especially the one used either as panel (base) or in the structure of style furniture, was the subject of extensive research on developing optimal solutions for moisture content and dimensional stability, protection against microbiological agents and xylophagous insects (insecticide and fungicide), thermal sources (fireproofing), fluctuations in the atmospheric humidity and rainfall (hydrophobation), of all microclimate and external factors (climate and mechanical protection by coating, and often giving an aesthetic look) (Hayashi *et al*. 2008, 2009, 2010a, b, Hunger *et al*. 2001, Sandu *et al*. 2007, 2008a, b, c and d, 2009a, b, 2010a, b, Siau 1995, Walker 2006). These treatments should not affect the aesthetics of surfaces or the polychromy for paintings, or the wood movement at the relative humidity.

In the ideal situation, for prevention, the treatment should be applied before or immediately after the art object is created because any subsequently interventions after long time can bring a number of shortcomings. For this purpose, the treatments must ensure a good retention for a long time, over 50 years (Vasilache *et al*. 2009, Hayashi *et al*. 2010a).

When it comes to treatments imposed by the occurrence of a specific effect of deterioration and/or degradation, is desired to be applied in as few steps as possible, easily and involving materials and processes which have minimal impact on wood.

There are known a number of modern methods to protect old wood from artifacts, by using some organic synergistic systems (Sandu *et al*. 2009b, c, d, Sandu *et al*. 2011b, c), with multiple functions in stopping the cumulative effects of deterioration and degradation with high penetrability in the volume phase, by forming a uniform nanocoating, compatible and with persistent retention.

Lately, the focus is on natural or semi-synthesis organic products, ecological, such as: paraffin and liquid petroleum derivatives, wax products, tannins, lignosulfonates, alkaloids, terpenes, flavones and others (Sandu 2008, Sandu *et al*. 2010 a, b, Sandu *et al*. 2011a, Vasilache *et al*. 2008, 2009).

Sandu *et al*. (2008) have developed a method to determine the normal range of equilibrium moisture content in wood within the limits that give microstructural destructions at fibrils and to the wood cells (moisture content: 0.5...1.5%), and the saturation point of the fiber (moisture content: 32...36%,) depending on the species, tree age, timber seniority, the state of preservation etc. This method has broad applications in the archaeometry field (at setting the temporal evolution of some characteristics, such as the time correlation of the two curves: the rate of hydration and dehydration ΔU, and so on) and to the impact studies of active preservation treatments (Hayashi *et al*. 2008, 2009, Sandu *et al*. 2009a, 2010).

The aim of this paper is to study, using the new patented method (Sandu *et al*. 2008) for determining the normal range of equilibrium moisture content in establishing the compatibility of organic solutions based on red oil and propolis, in the treatment of old linden wood for wood fiber enriching, insecticide, fungicide and hydrophobic (Hayashi *et al*. 2009, 2010a, Sandu *et al*. 2009a, 2010, Vasilache *et al*. 2009).

OBJECTIVE

The purpose of this paper is to present a study regarding the influence of natural organic products (propolis and red oil) used as a synergistic system, the compatibility with old lime wood over some physical and structural charateristics, which determines the wood movement under the influence of the air humidity.

EXPERMENTAL PART

For the study were taken samples of lime wood, 270 years old, the tree was 90 years old with active xylophagous attack (with deep quarries and many flight holes) and samples of the same species and age, without xylophagous or fungal attack. Samples came from the protection beams on the back of an iconostasis. From the two beams (one with and the other without xylophagous attack) were cut nine rectangular samples (first beam) with the sizes 40mm(L)x20mm(R)x10mm(T) and from the second one, six. For comparison were used samples of new linden wood with the tree age of 75 years and the oldness of 10 years.

From the first group, three samples were taken as reference, and the other six were divided in two, three were immersed in 20% alcoholic solution of propolis and the other three in red oil (petroleum) for 4 hours, after which they were removed, wiped with a cloth and placed outdoors to dry. In the same way the second group of six infested wood samples was divided in two, the first three of them were immersed in an alcoholic solution of 20%propolis and the other three in red oil for 4 hours, after which they were removed, wiped with a cloth and placed outdoors to dry.

After drying to a constant weight in normal atmospheric conditions, the four groups of treated samples (two not infested and two infested) along with the reference group (new wood) were subjected to consecutive processes of dehydration-hydration by determining the weight loss and the weight increase on which were drawn variation curves in time, on hygroscopic water desorption and adsorption. The variation of hygroscopic water content in the samples was determined using the correlation of two methods: the weight loss on drying

was measured by the Gravimetric method using an analytical balance ± 0.001g, Sotorius type, and with the Resistive Hygrometer with needle electrodes method.

For assessing the impact of treatment on wood were used three characteristics determined from the curves of hydration and dehydration, such as the equilibrium point given by the intersection of the two curves, the time necessary to achieve it, determined from the curve $\Delta U = f(t)$ and normal range of equilibrium moisture content; maximum and minimum humidity.

RESULTS AND DISCUSSIONS

Fig. 1 shows the curves of hygroscopic moisture in well preserved old lime wood (1905), at dehydration in the desiccator with RH 5% and at hydration in humidifier RH 99% HH, which is used as a standard.

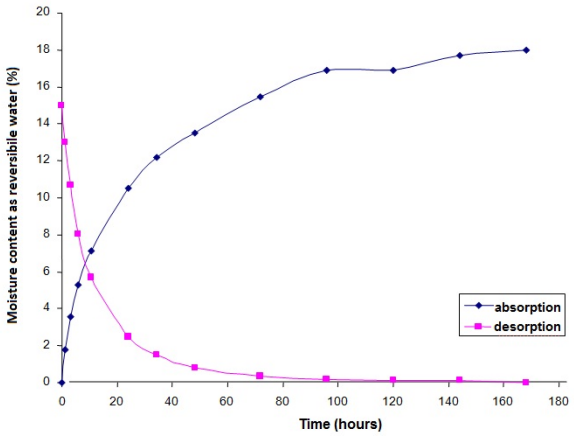

Fig. 1
Hydration and dehydration curves of in old lime wood.

From Fig. 1 it appears that the characteristic time of the two curves intersection for old wood well preserved, is 10.5 hours, corresponding to 6.4% moisture. According to previous studies (Vasilache *et al*. 2009, Hayashi *et al*. 2009) old linden wood, well preserved, dehydrates easier than the one hydric stabilized. Also, the maximum adsorbed moisture is 18%, compared to 12.5% for old wood well preserved (Vasilache *et al*. 2009).

Initially, the old wood, well preserved and the infested one, were treated separately with the two organic solutions of propolis and red oil (Figs. 2 and 3).

Figs. 2 and 3 allow the comparison of the effect of treatment with red oil and propolis over the hydration and dehydration curves on the basis of three characteristics: time and average correlation humidity of opposed hydric processes (adsorption and desorption of hygroscopic water) and maximum moisture adsorption of the reversible hygroscopic water. The data presented in Table 1, shows the impact of the two active principles used in the preservation (red oil and propolis) of change in normal range of equilibrium moisture content.

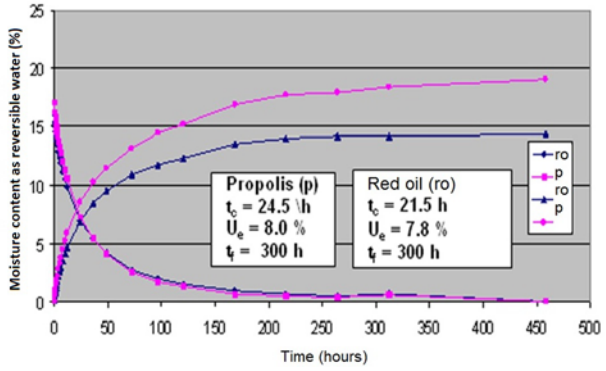

Fig. 2
Hydration and dehydration curves for old lime wood, well preserved, treated with oil red (ro) and propolis (p).

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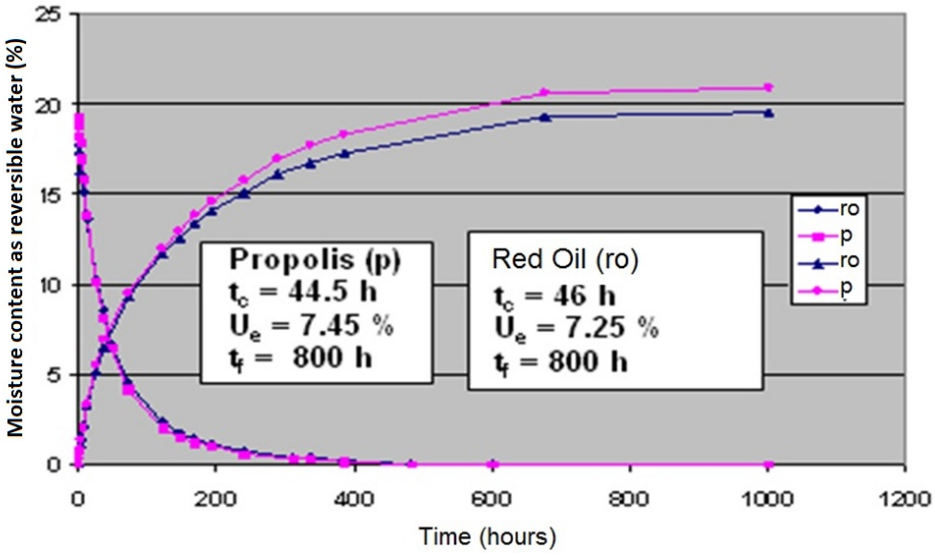

Fig. 3
Hydration and dehydration curves for old lime wood, infested, treated with oil red (PR) and propolis (p).

Table 1

Values of the characteristics involved in the impact study of lime wood treatments

No. crt.	Sample	Specific characteristic		Moisture content as reversible water		Change:			
		Time (hours)	U_c (%)	Limit (%)	Time (h)	t_c	U_c(%)	U_{Max}	t_{Max}(h)
1.	New lime wood*, well preserved, untrated	10.50	6.70	18,20	200	-	-	-	-
2.	New lime wood*, well preserved, treated with red oil	46,00	7,25	19,20	800	0	+3,35	+7,00	0
3.	New lime wood*, well preserved, treated with propolis	44,50	7,45	21,00	800	-1,50	+3,55	+8,80	0
4.	Old lime wood**, infested, untreated	8,50	6.40	18.00	200	-	-	-	-
5.	Old lime wood**, infested, treated with red oil	21,50	7,80	14,50	500	+13,00	+1,40	-3,50	+300
6.	Old lime wood**, infested, treated with propolis	24,50	8,00	17,50	500	+16,00	+1,60	-0,50	+300

* tree age of 75 years and the oldness of 10 years
** tree age of 90 years and the oldness of 270 years

This table shows that the time to reach critical moisture content in the correlation point in the processes of hydration and dehydration old lime wood, untreated and treated with red oil and propolis, compared to the new wood, increases of approx. four times, while the infested wood only by about two times. Humidity correlation increases sensitive in the series: *new wood untreated < new wood treated with oil red < new wood treated with propolis < old wood untreated < old wood infested treated with oil red < old wood infested, treated with propolis.*

These data prove that the two active principles do not significantly change the processes of sorption and desorption of the reversible hygroscopic water. Since the two types of wood are hydrophobic it was expected a decrease of maximum moisture with significant values.

Note that the time required to achieve maximum hydration and minimum dehydration (according to the method it was considered the hypothetical value equal to "0%") is 200h for the new wood untreated, 800H for treated new wood, respectively 500h for old treated wood.

Since the first experiments required high periods of monitoring the evolution of hydration and dehydration processes until reaching constant value, ranging between 200 and 800 hours, it was engaged in the study, the temperature factor, to decrease the duration of the experiment under 150 hours. In this case, it was considered that the average temperature of 35ºC hasn't got a negative influence on the processes of sorption - desorption of the moisture content, becoming possible for the conditions more rapidly to be achieved at minimum humidity at dehydration (RH <5%) and maximum moisture content(RH> 99%). It was used for this purpose an oven with thermoregulation, at 35ºC, where the samples were maintained during both experiments, hydration and dehydration.

CONCLUSIONS

By applying the treatment procedures using propolis in alcohol solution 20%, and red oil, which is the subject of a recent patented invention, the new linden wood acted differently from the old infested one. The treatment with the two components doesn't have a big influence on the variation of normal range in equilibrium moisture content. It ranges from very close limits of the characteristics of the two curves for the samples taken as standard (well preserved old wood and untreated wood).

This study enables the optimization of various organic solutions used for preservation and prevents the wood from fungal or borer insects attack, and waterproofing.

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