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THE EFFECTS OF HIGH TEMPERATURE ON GESSOES WITH DIFFERENT ADMIXTURES

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Abstract: *This paper presents the effects of temperature on gessoes that have different substances added, usually used in painting or restoration to enhance the flexibility of the ground layer or to create a suitable gesso for the specific painting technique. Five samples of gesso were made and applied on Balsa wood (a dry, stable wood that is used in restoration for completing the missing elements of the panel). After the thermal treatment, the samples were analyzed optical, by microscopy and colorimetry. The results showed small differences in colour, but no cracks of the gessoes.*

Keywords: gesso, temperature, colorimetry, panel paintings

1. Introduction

The panel paintings are made of wood covered with gesso (ground layer), painted with tempera or oil colours. The gesso varies in thickness, depending on period and location, from 2-3 mm (eastern European countries) to a few layers that cover only the spaces between the fibres (western and northern countries) [Sandu, 2006; Uzielli, 1995]. Its role is to make the wood surface smooth, so it can be painted in tempera or oil.

The gesso is usually made of animal glue (hide glue, rabbit glue) and gypsum or calcium carbonate. The main component of animal glue is collagen, a protein made mostly of glycine, alanine, proline and hydroxyproline. A collagen molecule is a helix associated with other two molecules by hydrogen bonds. When boiled, the collagen loses this organized structure and only when is cooled the molecules partially restore hydrogen bonds. The calcium carbonate and gypsum particles added to gesso enter between the molecular chains, reducing the number of hydrogen bonds and diminishing the tensile resistance [von Endt, 1991]**.** Some of these gessoes have other materials added (linseed oil, egg yolk), to make them more suitable for the technique (for example, a gesso without lipids will absorb the oil from the colours) or to avoid the appearance of bubbles in the ground layer [Véliz, 1995]. Another purpose for adding different substances is gesso flexibility. The in-fillings that complete the painting layer are made following the classic recipe of gesso, but, in order to make them more elastic, varnish or honey are added in small quantities. **[**Wadum, 1995]

The Balsa wood (*Ochroma pyramidale***)** used for experiments is a hardwood used in restoration for wooden objects completion, for reinforcing, because of its lightness and strength, and easiness in processing. Balsa wood shrinkage is 3% radial and 7,6% tangential. The shrinkage and swelling of wood under the influence of atmospheric factors are minor, once the wood is oven dry.

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Using different types of gesso and Balsa wood we analyzed the effects of high temperatures on gesso behaviour and aspect.

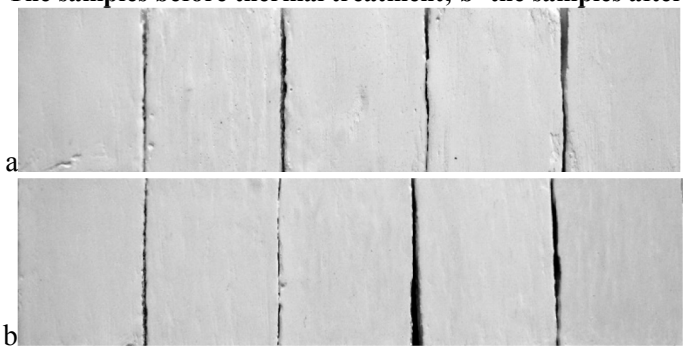
2. Experimental

For heating experiments there were used five samples of Balsa wood (3x2x1cm), which were coated first with warm hide glue (5%). After drying, gesso was applied. The gesso was made of hide glue 10% (53 g) and calcium carbonate (70 g). There were made five samples from this gesso, each weighing 22 g, in four of them different substances being added. One of the samples was kept free of extraneous substances,for comparison. The order of the samples was the following:

-sample 1: reference
-sample 2: 0,1 ml dammar varnish 40%
-sample 3: 0,1 ml linseed oil
-sample 4: 0,2 ml egg yolk
-sample 5: 0,1 ml honey

Six layers of gesso were applied on the wood samples. After drying, the samples were put in oven for 4 hours, and for another two sessions of 2 hours each, at 105°C (Fig.1a, b). After each session the samples were analyzed with the optical microscope type Zeiss Imager.a1M, which has attached a photo camera AXIOCAM and works with special software type Axion Vision Release 4.7.1. The colorimetric analysis was realized with a portable spectrophotometer type Lovibond RT 300.

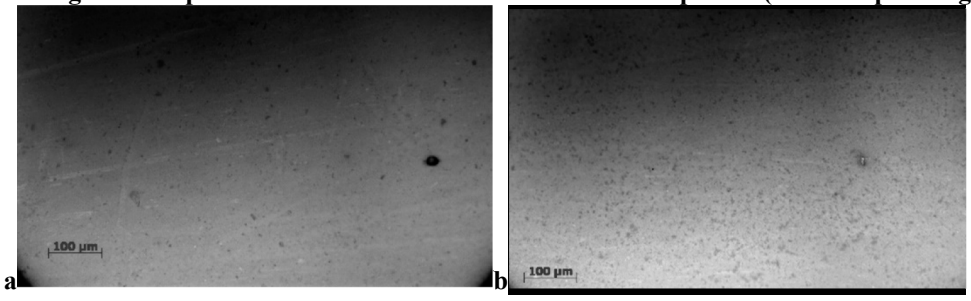
Figure 1a: The samples before thermal treatment; b- the samples after treatment



3. Results and discussions

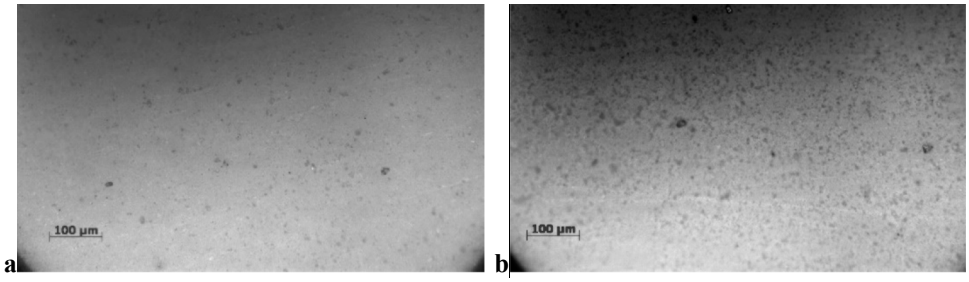
The microscopic observations made after exposing the gessoes to high temperature didn't reveal any cracks in the ground layer (Fig.2, 3). However, an increasing number of dark spots were noticed, probably due to thermal denaturation of proteins (Fig.2 b, Fig. 3b) [Day et al., 2002].

Figure 2: Images of sample 1 before and after 8 hours of thermal exposure (microscopic image 200X)



a **b**

Figure 3: Images of sample4 before and after 8 hours of thermal exposure (microscopic image 200X)



a b

The colorimetric analysis, using CIELab system, showed changes in gesso colour, more visible in the sample 5, where honey was added. Knowing that "L" indicates the luminosity of colours, "a" is the axis from green (-) to red (+), and "b" is the axis from blue (-) to yellow (+) [Schanda, 2007], we observe that the exposure to high temperatures increases the luminance for the samples 1, 2 and 4 (reference sample, dammar varnish and egg yolk, but decreases for samples 3 and 5 (linseed oil and honey). For the "a" axis the values are decreasing, except the sample no. 5 (honey), its hue going slightly towards red. Also, all the samples have increasing values for "b" axis, varying towards yellow, most noticeable being, again, the sample no. 5.

Table 1: L, a, b values for gessoes before exposing to high temperatures

CIE coordinates	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
L	95,34	93,94	94,38	93,81	93,62
a	+0,50	+0,36	+0,41	+0,41	+0,16
b	+3,28	+3,50	+3,66	+4,73	+4,37

Table 2: L, a, b values for gessoes after the final session of exposing to high temperatures

CIE coordinates	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
L	95,8	95,5	94,16	94,19	91,76
a	+0,14	+0,17	+0,11	+0,17	+0,37
b	+4,64	+4,93	+6,24	+5,86	+11,20

The CIELab colour difference was calculated after the following equation:

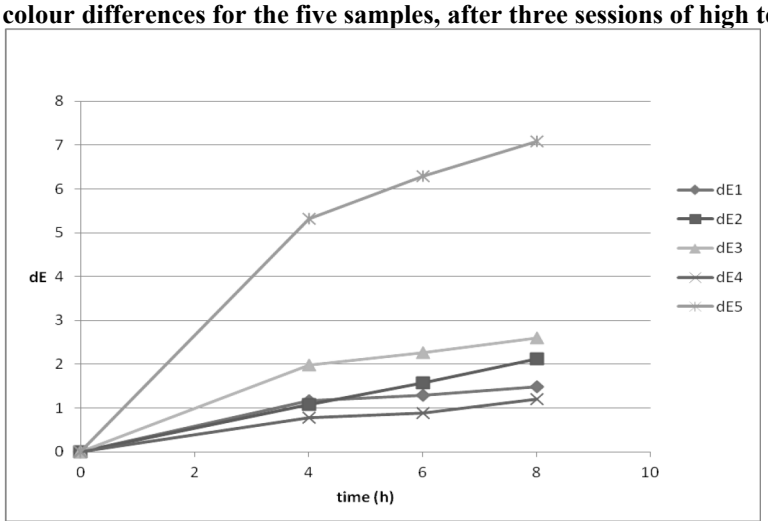
(1) $\Delta E^*_{ab} = [(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2]^{1/2}$ [Schanda, 2007],

where ΔE is the colour difference, ΔL^*, Δa^*, Δb^* are luminance and colour differences between the initial colour and the hue resulted after the exposure to high temperatures. Values of ΔE lower or equal to 2,3 show a bearably noticeable difference [Sharma, 2003].

Table 3: Colour differences after exposure to high temperatures

Time (h)	Colour differences (ΔE)				
	ΔE1	ΔE2	ΔE3	ΔE4	ΔE5
4	1,16	1,08	1,98	0,78	5,32
6	1,3	1,58	2,27	0,89	6,29
8	1,48	2,12	2,6	1,21	7,08

Figure 4: Chart of colour differences for the five samples, after three sessions of high temperatures



The visible colour change in sample no. 5 is probably due to the Maillard reaction which occurs when sugar condense with free amino-acids, one of the products being hydroxymethyl furfuraldehyde (furfural) [Annapoorani et al., 2010].

4. Conclusions

This experiment emphasized only the effects of the temperature on the gessoes. The heating treatment modified only slightly the colour of gessoes, but didn't induce the forming of cracks on their surfaces. The different substances added, apparently didn't make the ground layer more fragile. Future experiments will follow the effects of temperature and humidity variations on gessoes, also using different types of wood.

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