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THE THERMO LIGNUM ECOLOGICAL INSECT PEST ERADICATION PROCESS: THE EFFECTS ON GILDED AND PAINTED WOODEN OBJECTS

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Abstract

The present research study investigates the effects of a humidity controlled warm air treatment with the Thermo Lignum Process on gilded and painted wooden objects. The Thermo Lignum Process is an ecological and object-sensitive technique to combat insect infestations. The method only involves humidified warm air. It is founded on the established principle that most insects are reliably killed in all their life cycle stages at temperatures between 48 – 55°C depending on species. The infested objects are warmed up in a chamber to a maximum temperature of 51-58ºC. Throughout this treatment the air humidity is controlled in such a way that the EMC (equilibrium moisture content) in an object remains unchanged throughout the process. The typical chamber treatment cycle takes between 16 – 24 hours. The objects prepared for the study were examined before and after treatment by means of light microscopy, scanning electron microscopy and color measurements. Additionally investigations on potential distortion and adhesiveness to the substrates were carried out. In order to achieve the most comprehensive and meaningful result, the trial was carried out with three different groups of objects. Object group 1 consisted exclusively of samples of the binding agents most commonly used in historic finishes. Object group 2 included several newly applied finish layers, whilst Object group 3 comprised historical objects with different finishes belonging to a variety of style periods.

Keywords: *Thermo lignum process; Pest eradication; Polychromatic objects; Gilded objects; Painted objects; Wooden materials; Equilibrium moisture content; Keylwerth diagram; Insect pest control;*

Introduction

Art objects made of wood are often attacked by wood destroying insects. The larvae of these woodborers eat through the wood over a period of several years and the adult beetles deposit their eggs preferably on the same object, so that several generations of insect can cause substantial damage [1, 2]. Insect pest control is needed which has no adverse effects on the objects. The thermo lignum treatment offers an alternative to conventional eradication methods such as the fumigation of objects with toxic gases [3, 4].

Applications for the thermo lignum warm air method extend from objects made of wood [5], leather [6], paper [7], textiles [8] and photographs [2] to insect collections [3]; these

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materials have already been examined scientifically within the context with the thermo lignum process.

However, the behavior of polychromatic objects and the materials involved in this field has not yet been investigated. Involvement of modern methods of study materials from old paintings have in attention their nature and conservation status in order to establish protocols for the intervention of preservation and restoration (consolidation, insectofungical treatment, wet cleaning, structural and polychrome reintegration) [9-11].

The prime objective was to investigate the potential effects of a thermo lignum treatment on painted and gilded objects. For this purpose historical objects from a variety of style periods (17^{th} – 19^{th} century) with varying finishing coatings were examined by means of modern investigative methods before and after treatment [12-17]. It was also examined if the treatment had any adverse effects on the most commonly used resins and glues in the newly prepared samples both individually and as part of composite finishes.

Materials and Methods

Eleven historical objects with a variety of finish assemblies were examined as well as newly prepared samples. In the case of the latter, resins and glues were applied individually and in combination as complete finish assemblies to Swiss pine wood (Pinus cembra). In order to create a "worst case" scenario (in terms of very high resin content in this type of timber), Pinus cembra was chosen as substrate wood for this study. But glass and canvas were also used as substrate materials.

Table 1 provides a description of the historical objects which were examined. Table 2. provides an overview of the coatings applied to the newly made samples.

Table 1. Description of the historical objects examined

Object N°.	Date/Period	Description	Assembly
A_1	1900	Square altar section	Chalk rock foundation + gilding
A_2	1680	**Blossom**	Finish on finish, glue + chalk rock, several thick layers of gesso foundation + gilding
A_3	1770	Ornament	Gesso + gilding
A_4	1670	Acanthus leaf	Glue foundation + gesso + gilding
A_5	1756	3 Altar sections	Glue foundation + chalk rock foundation + Polonaise gilding
A_6	18^{th} cent. + 19^{th} cent.	Finger	2 finishes, original 18^{th} cent., refinished in 19^{th} cent.
A_7	18^{th} cent..	Large top section of an altar with marbling	Gesso + marbling with casein method
A_8	2^{nd} half 19^{th} cent.	Casing fragment	White and gold
A_9	2^{nd} half 19^{th} cent.	Foot fragment	White and gold
A_{10}	2^{nd} half 19^{th} cent.	Rosetta fragment	Gold on pressed cardboard
A_{11}	2^{nd} half 19^{th} cent.	Snail fragment	White and gold

The treatment is based on the principle that animal protein is damaged by the effect of elevated temperature, resulting in the death of all insect lifecycle stages (egg, larva, chrysalis, adult). The exact kill temperature and exposure time depends on the insect species. 55°C, held over one hour, is considered a reliable kill temperature for most wood boring insects.

The most important factor is to keep the object moisture content unchanged during the warming-up, the holding and the cooling phases [18, 19]. This is achieved by controlling the relative humidity in accordance with the Keylwerth Diagram (Fig. 1).

During all three phases (Fig. 2) - warming, holding, cooling – it is also vital that the Δt, the temperature difference between the object core and the room temperature (T_R equal to object surface) never exceeds a set limit. Both Δt and max T_R are object and material related and are based on empirical data.

Table 2. Description of the coating variants Type

Support type	Coating variant	Index samples	Description
		R_1	Shellac
		R_2	Mastic
	Resins	**R_3**	Dammar
		R_4	Copal
		R_5	Sandarac
On pine	Glues	**G_1**	Bone glue
		G_2	Rabbit skin glue
	Combinations	**C_1**	Gesso (Bologna chalk/Rabbit skin glue) + gilding
		C_2	Gesso (Bologna chalk/Rabbit skin glue) + oil finish
On glass	Glues	**G_3**	Carp glue
		G_4	Sturgeon glue
On canvas	"Combination aged and consolidated "	**C_3**	Oil paint on primed canvas (with zink oxide white) – consolidated with carp glue
		C_4	Oil paint on primed canvas (with zink oxide white) – consolidated with sturgeon glue

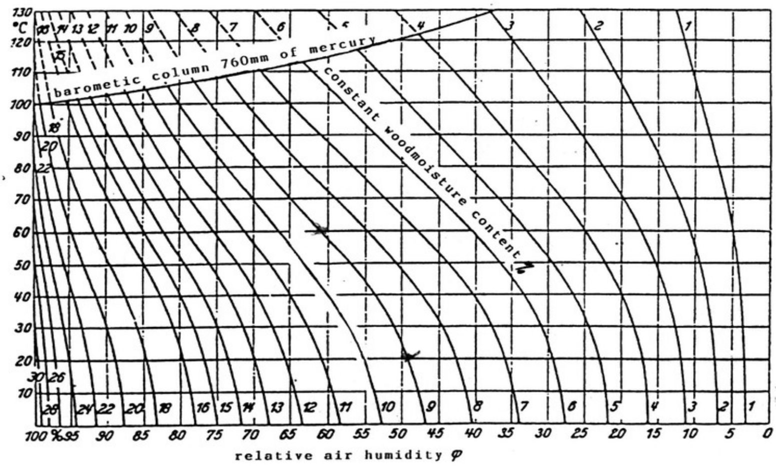

Fig. 1. The Keylwerth Diagram

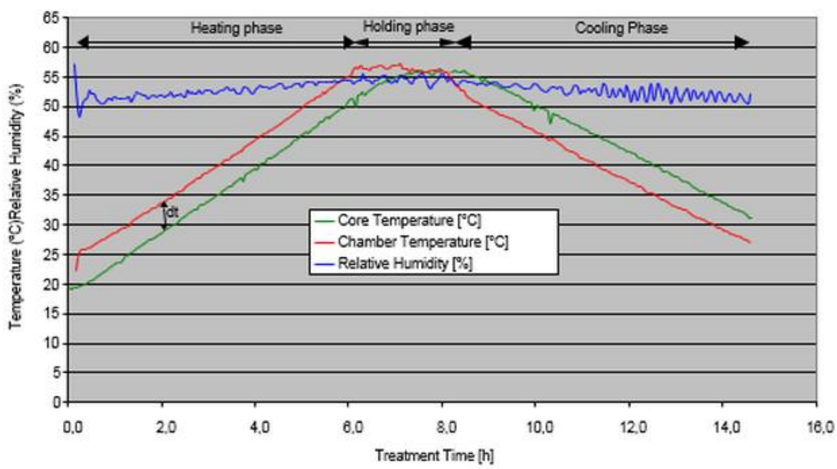

Fig. 2. Generic Diagram of a Thermo Lignum® Treatment

Apart from the analysis of the coating assembly of the historical objects, the investigation centered also on the layers of the resins and glues as well as other finishes applied to the pine wood samples.

The examination of the samples in the laboratory of Holzforschung Austria was based on the following parameters:

• Changes in the surfaces of all treated samples by means of microscopic assessment using optical microscopy (Olympus SZH) and scanning electron microscopy (JEOL JSM-6100)

• Cross sectional changes in the finishes or coatings (both optical microscopy and scanning electron microscopy)

• Changes in elasticity of the finishes or coatings applied to the newly prepared pine wood samples (examination to Austrian Standard ÖNORM C 2350).

Results and discussions

No changes could be found as a consequence of the Thermo Lignum method, neither in the historical objects, nor in the newly made-up samples, with the exception of the shellac-polished pine wood samples. The change in the shellac-polished pine wood samples consisted in the diffusion of resin droplets from the pine wood into the polish. However, the phenomenon of resin diffusion can also be observed under normal ambient environmental conditions, particularly in timbers with very high resin content.

No changes could be established through optical microscopy and scanning electron microscopy examination in the remaining, newly made-up samples, confirming that no dimensional changes had taken place. More specifically, the humidity-controlled warm air treatment did not result in any blistering, flaking, cracking or splitting in the coatings or polishes.

Particular attention was focused on potential changes in the cracks, evident already prior to the treatment, in the case of the canvas samples which were aged and consolidated with carp and sturgeon glue respectively (Variants C_3 and C_4). Again, no changes could be found during microscopy examination. (Figs. 3 and 4.) exemplifies a typical before/after photographic documentation (Sample C_4, see Table 2.).

No changes, as a consequence of the treatment, were found in the historical objects with optical microscopy and scanning electron microscopy examination, nor was there any reduction in adhesion strength or increased cracking in both the prepared coating samples and cross-sectional samples.

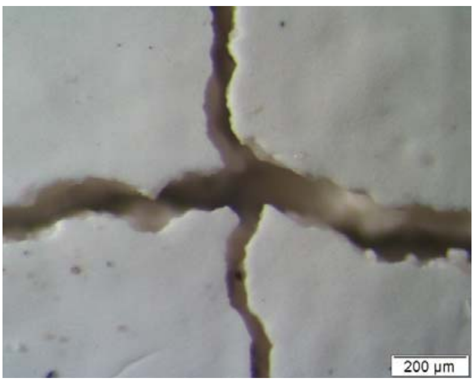

Fig. 3. Microscopic photograph of sample C_4 (aged and consolidated with sturgeon glue, on canvas) before the Thermo Lignum® Warmair treatment (magnification approx. 55 times).

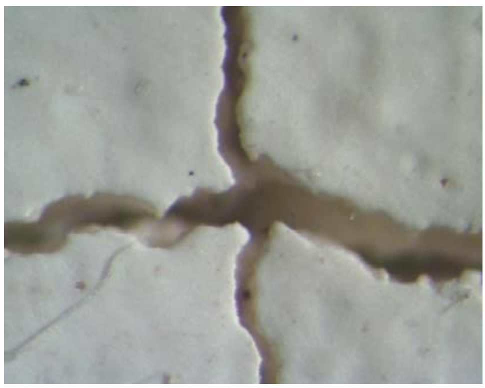

Fig. 4. Microscopic photograph of sample C4 (aged and consolidated with sturgeon glue, on canvas) after the Thermo Lignum® Warmair treatment (magnification approx. 55 times)

Figure 5 and 6 which shows a photographic image of Sample A_5, serves as an example of the macroscopic comparison.

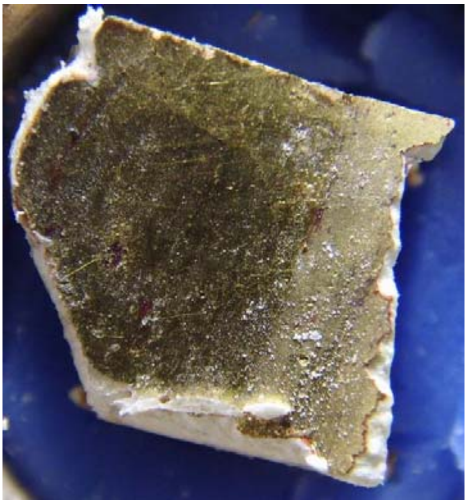

Fig. 5. Macroscopic comparison of sample A_5 - approximately 9 mm long (pre-treatment).

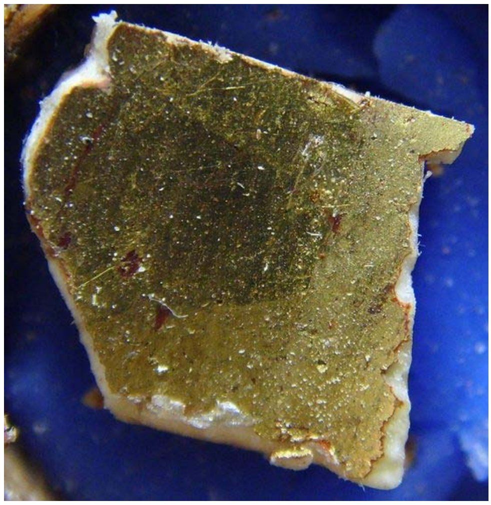

Fig. 6. Macroscopic comparison of sample A5 - approximately 9 mm long (post-treatment).

The Deformation Test to Austrian Standard ÖNORM C 2350 was unable to establish any change as a consequence of the Thermo Lignum® treatment in the deformation characteristics in the newly made-up pine wood samples.

Conclusions

Apart from the resin diffusion observed in the shellac samples, the present examinations did not detect any changes in the objects, neither in the historical samples nor the new samples.

It confirms the long-standing practical experience which underpins the use of the Thermo Lignum method as a means to eradicate insect infestations in historical objects of art with paint and gilt finishes without any adverse consequences for the objects.

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