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DETACHMENT AND TRANSFERRING OF OLD WOOD PAINTED ICON TO NEW SUGGESTED ALTERNATIVE SUPPORT

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Abstract
The paper describes the partial detachment and transferring of the painted layer of the private icon "Saint Mark" on a wooden panel to alternative support. Due to severe environmental conditions (relative humidity, temperature), poor storage and intense insects attack, the wooden panel becomes powdery and fills with holes and insect tunnels. Hence, it disables to do the major function as a support, carried and protected painted layer. The partial detachment and fixing painted layer on a new alternative support considered the important parts of the conservation process to this painted icon. Some investigation techniques used to provide a deeper understanding of the original wooden panel used, and deterioration phenomena on it include imaging [Visible (VIS), Ultraviolet-induced luminescence (UVL) and X-Ray radiography] and Optical Microscopy (OM). After that the authors made an experimental study, between suggested alternative support "15HL21 Piral HD Hydrotec Panel" and the same type of the original wooden panel of painted Icon "Willow wood". The alternative support, compared with the original wooden panel, proved successful toward artificial aging (i.e., heat, relative humidity, acids and alkalies). Plextol B500 was effective in fixing the painted layer to alternative support as an adhesive more than Beva 371 and Polyurethane isocyanate.
Key Words: *Detachment; Transferring; Icon; Adhesives; Alternative Supports.*

Introduction

The partial detachment and transferring of panel painting on to a new alternative support is a familiar technique. It used to protect the painted layer and helped it has a life as long as possible [1]. The major deterioration factors, which aided the decision-making process for partial detachment and transferring painted layer option, deteriorated wooden panel due to uncontrolled climate, poor stored and insect damage [2]. Along this line some investigation techniques approach has been used to provide a deeper understanding of the original wooden panel used in icon and deterioration phenomena [3-5].

This case study focuses on old private wood painted icon belongs to "Saint Mark" (Fig. 1), an unknown period and doesn't have a signature, from the Soviet Union. It measures approximately 30.4 × 20.3cm and thickness 1.3cm. Then, an experimental study was achieved to establish suitable procedures for the partial detachment and transferring of panel Painting on to a new alternative support "15HL21 Piral HD Hydrotec Panel".

Conservation State Assessment

The preservation state of the wooden painted icon was not a very good one. Because of the effects of the environmental conditions (such as high relative humidity and temperature) and human factors (such as poor storage) led to insect damage. The panel and the painted layers had

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suffered various types of degradation and deterioration. The panel had split, large insect tunnels run down through all icon and holes extended in the vertical position to include all painted layers. In addition to some areas of panel and painted layer had broken especially in edges of an icon (Fig. 2). Also, there are remains of the brittleness of the paper on the back of the wooden icon. These forms of deterioration could have serious consequences on the stability of the wooden painted icon.

Fig. 1. "Saint Mark" Icon (front and back)

Fig. 2. Conservation state of the wood painted icon: a) front showing holes, missing parts in edges of panel and looses in painted layer, b) back showing holes, missing parts in edges of panel and remains of brittleness of the paper

Experimental Part

Visual assessment

Visual assessment by the critical eye to determine the deterioration phenomena of the wood painted icon and the causes of deterioration may be easily identifiable. This method can also determine the most effective techniques of investigation to be applied for diagnosis the condition of the icon under study.

Technical photography (TP)

The technical images used to investigate the icon – visible (VIS) and visible-induced ultraviolet luminescence (UVL) were acquired with a Nikon D90 DSLR (CMOS sensor) digital camera modified for "full-spectrum" (between about 360 and 1100nm) and fitted with a Nikon Nikkor 60mm f/1:2.8D AF lens [6, 7]. For visible imaging the excitation was provided by two

photographic white light fluorescent sources and the camera lens was fitted with B + W 486 bandpass filter (c. 400-700nm) [8]. For UVL imaging the excitation was provided by two UV radiation sources (365nm) and the camera lens was fitted with B + W 420 and B + W 486 bandpass filter (c. 400-700nm). These imaging techniques can record the artistic characteristics of the icon, the surface layer of the sketches and deterioration phenomena in the wooden panel.

X-ray radiography

For X-ray digital radiography used Rigaku X. Ray Generator Portable Radioflex RF-200SPS, tube voltage 80 ~ 200kV, and wireless digital detector DXR250CU-W from General Electric Company. In this case, radiography could be indicated the nature of the wooden panel, much evidence of damage by insects and the position of nails and frame used in the construction of the painted icon. Also, it could be revealed the successive phases of the artist's creation (preparatory drawing, under paintings and changes of design).

X-rays are attenuated differently by the various areas of the painting depending on several factors including the energy of the radiation; density, thickness and composition of the paint layer; and the elemental composition of the support elements (ground, wood, frame, etc.). High Z elements absorb X-rays more efficiently than low Z elements; consequently, pigments that contain elements like lead (Pb), such as lead white, absorb more radiation and appear as light areas on the images. Cracks and tunnels do not absorb as many X-rays and appear dark. Generally, X-rays radiography was useful for restoration and conservation procedures [9, 10].

Optical microscopy (OM)

To identify the wood species, OPTKA MICROSCOPY (Italy) equipped with an OPTIKA B 9 Digital Camera in transmitted light was used. Thin sections of the wood panel to detect the kind of wood were obtained in the three principal anatomical directions: transverse (TS), tangential (TLS) and radial (RLS). The observation and description of the anatomical features for the sample were based on computer databases and wood anatomy atlases [11, 12].

To detect the adhering strength between the detachment painted layer and the new suggested alternative support, Digital microscope was used. It had a focus rang of (10–500mm), the magnification ratio of (20–200×).

Colorimetry

Konica Minolta Chroma Meter CM-700d Model IN Japan INC was used to register the rate of color changes for both the new suggested alternative support and Willow wood before and after aging. It was recorded in the CIE L*a*b* color space. The complete color deviation ΔE* is the sum of the changes in three color variables and is not able to determine the direction of color change, only the total amount. The chromatic deviation (ΔE*) was determined with the aid of equation [13-19]: in which:

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

ΔL* represents the change in light intensity in the respective point, at different time intervals, as compared to the initial value: $\Delta L^* = L_f^* - L_i^*$; Δa* represents the chromatic modification of the coordinates of axis a* (colours blue and green), from the same point, at different time intervals, as compared to its initial value: $\Delta a^* = a_f^* - a_i^*$; Δb* represents the chromatic modification of the coordinates of axis b* (colours blue and yellow), while respecting the same method of calculation: $\Delta b^* = b_f^* - b_i^*$.

Weight scale

Shimadzu UX320G UniBloc top balance was used to register the weight. All samples for both the new suggested alternative support and Willow wood were weighed before and after

aging and by applying the law of mass rate. The percentage of the weight change has been calculated according to equation [20]:

$$\text{Percentage of the weight change} = \frac{\text{Sample mass after aging} - \text{Sample mass before aging}}{\text{Sample mass before aging}} \quad (2)$$

Bending resistance Testing

The bending resistance was done using a universal testing machine LK10k (Hants, UK) fitted with a 5kN load cell, and operated at a rate of 5mm/min on the samples that were cut to suit the operating conditions of the machine for bending test.

Results and Discussion

The first experimental study

It was applied between models of the new suggested alternative support "15HL21 Piral HD Hydrotec Panel "and the models of the same type of the original wooden panel of painted icon "Willow wood".

Aging and Tests

Samples of new suggested alternative support and Willow wood were prepared of $10 \times 1 \times 1cm$ in dimensions for Color change testing, Weight scale testing, and bending tests.

Artificial aging: Samples were exposed to heat and relative humidity aging cycles (60ºC and 8% RH) for 100 hours [21].

Aging by acids and alkalies: Other samples of new suggested alternative support and Willow wood were exposed to locally to conc. acid hydrochloric (HCl) and sodium hydroxide (NaOH) for 12 hours [21]. After three hours, the Willow wood was etched, while the suggested support showed no changes. After 12 hours, more etching with more depth was noticed on Willow wood; but only a very light white layer that can be easily removed by mechanical means was noticed on the suggested support. This result indicates the high durability of the suggested. The samples were tested before, during, and after aging as follows:

Color change testing: The samples aged new suggested alternative support and Willow wood were characterized by a significant change in color degree compared to standard samples. Color change is a reflection of the chemical changes that occur [22]. The results of color change testing were shown in (Tables 1 and 2). By comparing the results of color change for both new suggested alternative support and Willow wood, the color change was appearing high in Willow wood.

Table 1. The results of color change test before, during, and after artificial aging.

(15HL21 Piral HD Hydrotec Panel) New suggested alternative support				
Color change rate	**Before aging**	**After 25h**	**After 50h**	**After aging**
ΔL*	-3.86	-4.47	-4.78	-4.78
Δa*	0.34	0.44	-0.64	-0.64
Δb*	1.55	1.87	2.01	2.01
ΔE*	4.17	4.87	5.23	5.23
Original wooden panel of painted Icon (Willow Wood)				
ΔL*	6.51	6.33	5.42	4.14
Δa*	-0.45	1.00	-0.67	0.27
Δb*	2.49	0.38	1.17	2.06
ΔE*	6.98	6.42	5.25	4.63

Weight change testing: The samples aged new suggested alternative support and Willow wood were weighted to calculate the percentage of the weight change. The results of weight change testing were shown in (Tables 3 and 4). The results showed that the rate in weight

change of new suggested alternative support is lower than the rate in weight change of Willow wood.

Table 2. The results of color change test before, during, and after aging by acids and alkalies.

Type of aging	Aging by acids				Aging by alkalies			
(15HL21 Piral HD Hydrotec Panel) New suggested alternative support								
Color change rate	**Before aging**	**After 3h**	**After 6h**	**After aging**	**Before aging**	**After 3h**	**After 6h**	**After aging**
ΔL*	-1.88	2.74	2.98	-3.22	-27.69	-26.2	-25.62	-25.15
Δa*	-0.11	0.67	0.51	0.03	-0.16	0.04	0.05	0.07
Δb*	-0.14	0.61	0.58	0.43	0.61	0.27	1.30	0.54
ΔE*	1.89	2.89	3.08	3.24	27.70	26.20	25.65	25.16
Original wooden panel of painted Icon (Willow Wood)								
ΔL*	0.59	1.11	3.58	3.10	-23.44	-3.99	-7.97	-5.23
Δa*	3.14	2.56	1.32	1.45	6.61	0.31	0.94	0.15
Δb*	9.60	5.31	3.30	3.00	18.63	10.15	10.56	10.42
ΔE*	10.12	5.59	5.04	4.55	30.73	15.62	13.27	11.66

Table 3. The results of Weight scale test before, during, and after artificial aging.

(15HL21 Piral HD Hydrotec Panel) New suggested alternative support				
Hours of aging (h)	**Before aging**	**After 25h**	**After 50h**	**After aging**
Weight(gm)	1.11	1.11	1.11	1.11
Percentage of the weight change (%)	0			
Original wooden panel of painted Icon (Willow Wood)				
Weight (g)	1.87	1.84	1.77	1.75
Percentage of the weight change (%)	0.064			

Table 4. The results of Weight scale test before, during, and after aging by acids and alkalies.

Type of aging	Aging by acids acids				Aging by alkalies			
(15HL21 Piral HD Hydrotec Panel) New suggested alternative support								
Hours of Aging (h)	**Before aging**	**After 3h**	**After 6h**	**After aging**	**Before aging**	**After 3h**	**After 6h**	**After aging**
Weight (g)	1.24	1.29	1.25	1.25	1.20	1.32	1.23	1.23
Percentage of the weight change (%)	-0.008				-0.025			
Original wooden panel of painted Icon (Willow Wood)								
Weight (gm)	1.82	2.01	1.93	1.84	1.88	2.34	2.21	2.05
Percentage of the weight change (%)	-0.011				-0.90			

Bending resistance testing: The bending resistance is the property related to the behavior of suggested alternative support and Willow wood when subjected to stress because of changes in temperature and relative humidity. The bending resistance indicates stiffness which has been inversely proportional with flexibility [23]. According to the results of bending resistance testing (Table 5); the Willow wood is stiffer than the new suggested alternative support. So that, the flexibility of the new suggested alternative more than the flexibility of the Willow wood.

Table 5. The results of bending stress test before, during, and after different types aging.

Bending stress testing (N)	(15HL21 Piral HD Hydrotec Panel) New suggested alternative support	Original wooden panel of painted Icon (Willow Wood)
Stander samples	23.14	32.78
Samples after aging by alkalies (12h)	17.13	35.99
Samples after aging by acids (12h)	25.05	39.73
samples after artificial aging (100h)	20.53	26.60

The second experimental study

It was compared between three materials to prove that could succeed as an adhesive using in fixing the painted layer to alternative support. The first material is *Plextol B500*. It is methyl methaacrylate and ethyl acrylate copolymer belonging to the group of acrylic resin acqueous dispersion. It used in conservation as adhesives and consolidates for different materials. The solid contents are approximately 40% [24].

The second material is *Beva 371* that was developed by Gustav A. Berger and is predominantly used for lining paintings, facings and laminates. It is a mixture of ethylene-vinyl copolymers and hydrocarbon resins in petroleum solvents of about 55% aromatic content, the solid contents is approximately 40% [13].

The third material is *Polyurethane isocyanate*, which was obtained readily from the Egyptian market and sold as a closed package [25].

Models of new suggested alternative support were prepared of 5×5×1cm in dimensions for adhering detachment painted layer.

Visual observations revealed the preliminary success of four adhesives for fixing the painted layer on the new suggest alternative support. This will be further confirmed after artificial aging.

Artificial Aging and Evaluation of adhesives

Models of detachment painted layer fixed on the new suggested alternative support were exposed to heat and relative humidity aging cycles (60ºC and 80% RH) for a period of 12, 24, 36, 48, 60, 72 hours [21].

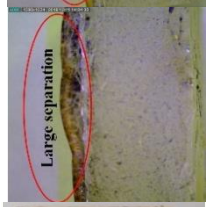
Table 6 illustration evaluation of adhesives used to adhere painted layer on new suggested alternative support (15HL21 Piral HD Hydrotec Panel) by using ultraviolet (UV) of Dino light digital microscope, AM41152T (20×).

Wooden Panel

Identification of Wood Species

The microphotographs of wood thin sections (Fig. 3) showed that Willow (salix sp.) was used for making the icon support. White Willow is recorded as being native to Europe and Asia. This is confirmed that icon from the Soviet Union. The xylem within the genus salix is very homogenous and species cannot be distinguished. The transverse section showed ring bound distinct by the difference in vessel size between latewood and earlywood and by radially flatted latewood fibers. Wood semi-ring porous, vessels solitary or in radial multiples of 2– 4 elements. Mean tangential diameter of earlywood vessel 20 - 50µm, 100 – 200mm^2. Gums and other deposits in heartwood vessels. Axial parenchyma scanty paratracheal. Rays 12 – 20 per mm. The radial section showed simple perforation plates and Inter - vessels pits alternate, as well as body ray cells procumbent with one row of square marginal cells. Tangential section showed rays are exclusively uniseriate [12].

Table 6. Evaluation of adhesives used to adhere painted layer on new suggested alternative support (15HL21 Piral HD Hydrotec Panel) by using U.V microscope (20×)

Type of aging	Beva 371	Plextol B500	Polyurethane
Before artificial aging			
After artificial aging (12h)			
After artificial aging (24h)			
After artificial aging (36h)			
After artificial aging(48h)	-		
After artificial aging (60h)	-		-
After artificial aging (72h)	-		-

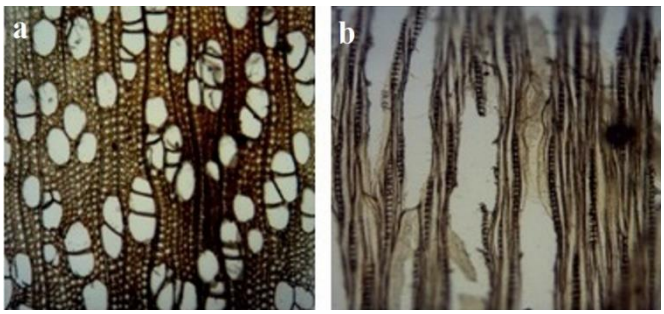


Fig. **3**. Microphotographs of wood sections under the microscope in transmitted light (100X) showing the anatomical characteristics of Willow:
a) transverse section; b) tangential longitudinal section.

Deterioration phenomena of Wooden Panel

These imaging techniques showed deterioration phenomena in wooden panel (Fig. 4.). The large insect tunnels run down through the wooden panel and holes extended in a vertical position to include the wooden panel and all painted layers. In addition to some areas of panel and painted layer had broken especially in edges of the icon. So, we must make of partial detachment and transferring of panel painting on to a new alternative support.

Fig. 4. the defference images of the wood painted showing the large insect tunnels and holes in wooden panel of icon:
a) visible; b) UV luminescence; c) Radiographic image

The new suggested alternative support "15HL21 Piral HD Hydrotec Panel"

It is made of a polyurethane foam panel coated with 80-micron thick aluminum foil. The aluminum foil is coupled with a g/m^2 layer of corrosion-resistant polyester paint. 15HL21 Piral HD Hydrotec Panel characteristics are shown in (Fig. 5).

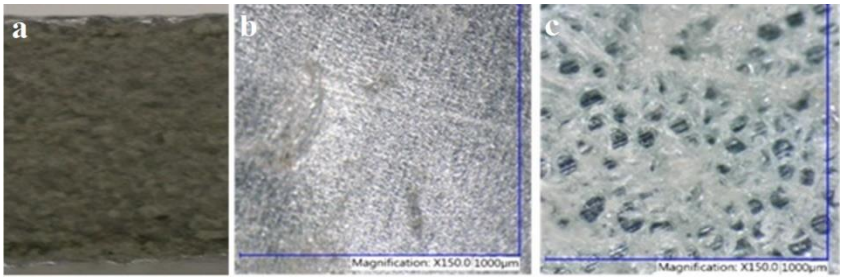


Fig. 5. 15HL21 Piral HD Hydrotec Panel characteristics: a) cross section in external aluminum, polyester lacquer and polyurethane from outside, b) external aluminum from outside by digital microscope, c) cross section in external aluminum, polyester lacquer and polyurethane from inside by digital microscope

External aluminum: the thickness of (0.08mm) embossed and protected with polyester lacquer. Internal aluminum: the thickness of (0.08mm) embossed and protected with polyester lacquer. Insulation component: polyurethane density of 52±2kg/m^3. Thickness: 20mm. Thermal conductivity: 0,022 W/(m°C) at 10°C. Fire reaction: class "0" - "1". Stiffness class: R 200.000 [20].

According to the color change, weight scale and bending resistance testing (Tables 1, 2 and 3), the results of aging characteristics to the new suggested alternative support "15HL21 Piral HD Hydrotec Panel " is better than the original wooden panel of painted icon "Willow wood". Visual and microscopic observations revealed that the detachment painted layer which was fixed to the suggested support using Plextol B500 is more durable than the other adhesives which were fixed by using Beva 371and Polyurethane isocyanate (Table 4).

Preservation Procedures

The poor condition of the wooden painted icon was found to need the partial detachment and transferring of the painted layer to the new suggested alternative support. The treatment of the wooden painted icon was undertaken as follows:

First, the normal methods of removing old nails, which fixed the frame to the wooden painted icon, were used to remove the frame easily by pliers. Then, the painted layer, which was ready to remove loose dust by gentle brushing and white spirit, consolidated by a solution of 5% and 10% of Beva 371 in white spirit by using brush [26].

Before the partial detachment and transferring of panel painting carried out, we applied some procedures to reinforce the painted layer. Two further complete layers (Japanese tissue paper) of facing were applied over the whole painted surface with a solution of 5% Beva 371 in white spirit (Fig. 6a) [27].

Fig. 6. Conservation procedures for “Saint Mark” icon:
a) Facing painted layer; b) The painted icon after partial detachment of wood panel;
c) After fixed the painted icon to the new suggest alternative support and retouched the painted layer;
d and e) Front and back of icon after conservation

Consequently, the painted surface was placed downwards upon a very even table, and there fixed evenly; the wood panel must then be planed off with the greatest care to scrabble with a sharp instrument like a razor, scalpel, and chisel until the thickness of wood was 3mm (Fig. 6b) [1].

After the partial detachment, the pained layer hadn't been exposed to any stress, while the remaining of original wood in the back of the painted layer was consolidated by hydrocarbon resin (regalrez1094) [28]. Then three layers of tissue paper were glued to the remaining of original wood using Plextol B500 as well. The next step involved spreading a layer of Plextol B500 on the new suggested alternative support (15HL21 Piral HD Hydrotec Panel). The painting was then placed on the new suggested alternative support (Fig. 6c). This had followed by placing weights on the new suggested alternative support to complete adhering the painted layer on the new alternative support until the adhesive had got dry. After the painted icon was fixed to the new suggested alternative support, the tissue papers were removed.

The holes and the losses parts in the painted layer were filled by acrylic ground layer, Acrylic maimeri colors that are more stable, do not melt in water, resist climate changes and have good adhesion [29], were used for retouching (Fig. 6c). After complete dryness of the paint layer, the surface of the icon was re-varnished using the modern matt acrylic varnish, (bdacril, methyl methacrylate), which has been applied by spray where the icon was put on a flat table to cover all parts of the painting surface during spray [30].

Finally, the painted icon was fitted into the original frame secured by carrying a new technique. The design is very simply constructed consisting of four pieces of Plexiglas, which formed as (Z), held in the middle painted icon and frame and fixed with small nails in the side of the wooden frame. This design is been suitable for the thickness of the new suggest alternative support. Figure 10d, e showed the icon after conservation.

Conclusion

This paper presents the partial detachment and transferring of the painted layer of the private icon "Saint Mark" on a wooden panel to alternative support. An uncontrolled climate, poor stored and insect damage were the major deterioration factors to make partial detachment and transferring the painted layer. This is a familiar technique. However, determined the kind of alternative support is a very difficult choice, due to the numerous disadvantages of traditional alternative supports either the ones used for oil paintings. With the help of some investigation techniques, the wooden panel of the icon was identified as Willow (Salix sp.). We observed the deterioration phenomena in the wooden panel (the large insect tunnels and holes).

The new suggested alternative support "15HL21 Piral HD Hydrotec Panel", which used for transferring the painted layer, compared with the original wooden panel of painted Icon "Willow wood". The new suggested alternative support proved successful toward artificial aging (i.e., heat, relative humidity, acids and alkalies). Plextol B500, compared with Beva 371 and Polyurethane isocyanate, proved successful as an adhesive used in fixing the painted layer to alternative support. These practical results of the experimental study were applied to the wooden oil-painted icon "Saint Mark". Also, it had undergone a considerable number of traditional treatments. The new suggested alternative support showed excellent results especially in absorbing shocks if the painting falls for any reason. Moreover, it allows the fixing of the original frame to display purposes. So that, we suggested using a new technique to fix the original frame of the painted icon again. It depended on using pieces of Plexiglas and fixed by nails to be suitable for the thickness of the new suggest alternative support.

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