Conservation and analysis of a Qajar lacquered painting from Helwan University Museum, Egypt

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Abstract
A Qajar lacquered painting applied on pasteboard support from the Applied Arts Museum of Helwan University has been investigated and conserved. The painting support was manufactured from two distinct layers of which the thick under layer was made of paper sheets pasted together, pasteboard, and the thin upper layer was a finer layer of fibers. The support comprises cotton fibers with some additions such as kaolin and gypsum as revealed in the FTIR analysis. Human hair and straw were also added to the pulp to strengthen the support. Two pigmented preparation layers were applied of which the main layer, is blue and was applied as a mixture of lazurite and/or indigo while the margin of the painting was applied on a red preparation layer. The pigment palette as revealed by Raman microscopy comprises; Lapis lazuli, indigo, orpiment, red lead and malachite. The FTIR spectra for the lacquer layer suggested the application of shellac resin. The highly needed conservation treatment was carried out including; cleaning, securing the detached paint layer and splitting paper sheets, deacidification, retouching and varnishing. Finally, a museum-grade display box was created and labelled.

Keywords:
lacquer, pasteboard, pigments, shellac, conservation
1. Introduction

Persian lacquered objects including; pen boxes, book covers, jewellery boxes, paintings, albums, mirror cases, folding screens, scale boxes and doors are widely spread in many Islamic museums all over the world. However, analytical studies of the materials used as well as restoration/conservation studies of this type of object are very limited (Purinton and Watters, 1991; McSloy, 1999; Abdel-Ghani, 2022). Most performed studies focused on Chinese and Japanese lacquer objects (Webb, 1998; Heginbotham et al., 2008; Pittard et al., 2010).

Technical differences between the Persian lacquer and the lacquer of China and Japan are well-known. The latter was usually applied on wood and the design was built up, often in relief, by a sequence application of lacquer, the gummy exudation of rhus vernicifera, coloured or enriched with powdered metal and polished. In Persian lacquer, the decorations were mostly applied on papier mâché/pasteboard and the surface was thinly coated with a fine plaster or gesso then the painter executed his design in the miniature painting technique of the time. The decorations were then covered with a layer of transparent lacquer or varnish. This transparent lacquer not only protects the painting but enriches the colours as well (Robinson, 1989). In some instances, the brilliance of the varnish was further enhanced by adding powdered gold or powdered mother of pearl to reveal a special effect known in Persian as marqash (Carvalho et al., 2001).

Persian lacquered objects first appeared in the late 15th century as book covers which were made of paper sheets pasted together, and decorated with gold arabesques on a black background (Khalili, 2005). The book covers continued in production from the 15th century through the Qajar period. Pen boxes were manufactured in the late 17th century while mirror cases and caskets were manufactured during the 18th century. In the Qajar period, further items were produced such as; small letter seals and playing cards (Robinson, 1989).

This craft reached a high state of development under Fath-Ali Shah (1797- 1834), but the best work was produced under Nasr al-Din Shah in the middle of the nineteenth century (Robinson, 1967).

1.1. The studied object

The object under study is a rectangular Persian lacquered painting from the Qajar period, measuring 21 cm W x 9.4 cm L. The object is not functioned, however, from its measurements, it may be assumed to be an album binding. It is exhibited in the Faculty of Applied Arts Museum, Helwan University (Giza, Egypt) with registration number 100/6 in the museum archives.

In the centre of the scene lobed medallion that comprises a man repose on a big pillow and extending his legs putting one above the other. The characters in the scenes wear the famous Persian dress known as Qibaa in green. The main character, sitting on a white carpet decorated with floral implemented with thin black lines, wears a white shawl around his waist and another red shawl on his shoulder. He also wears the Safavid turban with folds. His left hand is extended to pick a
Pomegranate from the tree standing in front of him. The background of the scene shows the front of a palace and its dome decorated with geometrical designs, consisting of parts of a star polygon, eight-pointed stars and others in the cross shape. The main colours applied in the decorations are; red, black, green, white and yellow. The Khatai floral scrolls surround the medallion in the middle with light and dark green simple leaves and the lotus flowers by the blue, yellow, red and orange colour.

1.2. Conservation assessment

The painting was covered with dust accumulations on the surface and the reverse as well as between the splitting papier-mâché and a disfiguring dull yellow varnish was concealing the decorations underneath. Many areas of the ground layer were missing (figure xxx). Cleavage and loss of the paint layers in many areas along with lifting and splitting through the papier-mâché support were displayed (figure xx). Museum registration numbers were written on two yellow self-adhesive labels and were attached to the recto and verso with crossed stripes of adhesive tape. There is also evidence of old restoration treatment, which was apparent by the existence of a red strap of paper adhered to one side and through the thickness of the reverse side.

This research is the second of the project concerning with examination and conservation of Qajar lacquered objects. It aims to study the technology and the materials employed on a small Persian lacquered painting, probably album binding, to conduct the required conservation treatment.

Figure 1. The images of the studied painting; a) the verso side, b) the recto side

Figure 2. Auto-Cad outline showing the main deterioration aspects of the painting

2. MATERIALS AND METHODS

Samples from damaged areas were taken using a scalpel. The samples under study comprise pasteboard support, lacquer, and paint samples including; red, orange, blue and green. The samples were studied non-destructively using Fourier transform infrared coupled with attenuated total reflectance "FTIR-ATR" and Raman microscope.

Raman spectra of the pigments were collected using a Senterra spectrometer (Bruker) coupled to a confocal Raman spectroscopy (20x - 100x objective lens), operating at near-IR laser diode emitting at 785 nm. The average spectral
resolution in the Raman shift range of 100–2000 cm\(^{-1}\) was 4 cm\(^{-1}\).

A Bruker FTIR spectrometer, model VERTEX 70 equipped with ATR was used. The IR spectra, in absorbance mode, were obtained using an aperture of 20–100 \(\mu\)m, in the spectral region 600 to 4000 cm\(^{-1}\) with resolution 4 cm\(^{-1}\) and the number of co-added scans 64 for each spectrum.

3. **RESULTS AND DISCUSSION**

3.1. Technology and structure of the painting

Figure 3 shows the schematic structure of the examined painting. The substrate was created from papier-mâché, comprising two distinctive layers of which the uppermost was made of a finer paper paste. This structure meets the description of Khalili for papier-mâché making (1988) which emphasize placing a superior paper sheet on top of lower quality sheets (Khalili 1988). Straw and hair enclosures were added to the sheets for reinforcement (figure c).

No white preparation layer was detected; instead blue and red under layers were distinctively executed on the lobed central medallion, and the outer floral decoration areas respectively.

![Figure 3. The schematic structure of the foot case](image)

3.2. **The paper support:**

Figure 4 shows the ATR-FTIR bands of the pasteboard support and their assignments related to components [36, 40-42]. When revising the FTIR spectra, it was inveterate that the pasteboard support is made of pulped rags (cellulose 3333, 3288, 2902, 1642, 1536, 1426, 1370, 1333, 1316, 1279 and 1247 cm\(^{-1}\) (Pandey and Pitman 2003), ion et al, 2008). Calcite (calcium carbonate CaCO\(_3\)) (~ 1426, 875 cm\(^{-1}\)), gypsum (calcium sulfate CaSO\(_4\)) (~ 1150 and 662 cm\(^{-1}\)) [45] and kaolinite (Al\(_2\)O\(_3\)·2SiO\(_2\)·2H\(_2\)O) (3694, 1621, 1006 and 912 cm\(^{-1}\) (Saikia, 2010) were added as fillers to the pulp (figure).

It also revealed that the paper boards could be pasted with animal glue as defined by the presence of amide I, II, and III bands at ~ 1642, 1536, and 1316 cm\(^{-1}\) respectively [44].

![Figure 4. The FTIR bands of the pasteboard support; (a) the upper paper sheet (b) the coarse under sheets](image)

3.3. **The lacquer layer**

According to literature, the Persian varnish used in paper artworks is shellac or sandarac resins (khalili 1988, Abdel-Ghani 2022). The FTIR-ATR spectrum of the lacquer varnish matched well with the reference spectrum of shellac resin. The spectrum includes O–H stretching bands at 3413 cm\(^{-1}\), CH2/CH3 stretching modes at 2926 and 2855
cm⁻¹, C=O stretching of and carboxylic acid bands at 1709 cm⁻¹, C=C stretching at 1631 cm⁻¹. At the fingerprint region, bands exhibited at 1453 cm⁻¹ and 1378 cm⁻¹ from CH2/CH3 bending and deformation (Derrick, 1999).

3.4. **The paint layer**

3.4.1. **The red paint**

The red pigment was used for two different functions (functioned in two different purposes); the first as an underpaint that served as a background at the edges of the paintings, and the second as a red paint depicting the flowers, the fruits and the shawl on the shoulder of the main character. The Raman spectrum of the red paint gave the principle features of red lead Pb₃O₄ with its bands at 122, 149 and 548 cm⁻¹.

3.4.2. **The orange paint**

Orpiment was the pigment chosen for the orange hue applied on the painting. It was also used with the blue pigment, indigo, for creating the green of the garment. The Raman spectrum of the orpiment shows the distinctive bands at 137, 154, 179, 202, 294, 310 and 356 cm⁻¹ (figure 5).

Orpiment is a yellow arsenic sulphide (As₂S₃) mineral which has been used extensively as a pigment both in its natural and synthetic forms. Purinton and Watters mentioned the availability of sulphide ores from the local sources in Iran (Purinton and Watters, 1991).

2.4.3. **The blue pigments**

Raman analysis of the blue colour in several areas of the painting gave two different spectra attributable to indigo and lazurite. Indigo was mainly used as an underpaint in the lobed central medallion and lapis-lazuli, was applied as the main blue pigment spread throughout the painting. Lapis-lazuli was distinguished by its strong band at 543 and weaker bands at 259, 1095, 1161 cm⁻¹ (figure 6), while indigo showed its characteristic bands at 1016, 1247, 1307, 1365, 1571 and 1630 cm⁻¹.

Indigo was manufactured from a assortment of plants of which the most distinguished is Indigofera tinctoria Indigotin C₁₆H₁₀N₂O₂, (Abdel-Ghani et al., 2012; Abdel-Ghani, 2022). Although, indigo was cultivated in Iran, it was normally acquired from Bengal (Khalili, 1988) as the industry of making indigo was not known in Iran (Barkeshli, 2013).

Lapis lazuli is a sulphur-containing sodium aluminium silicate mineral with the common formula (Na₈[Al₆Si₆O₂₄]S) (Abdel-Ghani, 2022).
It was obtained, by the Persian painters, from northern Afghanistan mines (Barkeshli, 2013).

Figure 6. The Raman spectrum of the blue paint, Lapis lazuli.

3.4.4. The green paint

Three shades of green were recognized. The green of the garment was found to be a mixture of indigo and orpiment as revealed by the Raman spectrum. The characteristic of indigo shows at 1016, 1221, 1307, 1365, 1571 cm\(^{-1}\) and the bands of orpiment 380, 351, 308 and 277 cm\(^{-1}\). The same composition was revealed in other spots of darker green. The difference in the shade may be due to the proportion of the pigments present in each sample. The third shade of green was found to the green chrome malachite, CuCO\(_3\).Cu(OH)\(_2\) with its well identified Raman shifts at 155, 178, 265, 437 and 540 cm\(^{-1}\).

Table 1. comparison between the studied painting (the small painting) and a previously studied painting (the big painting)

<table>
<thead>
<tr>
<th>Varnish</th>
<th>Single lacquer layer</th>
<th>Multiple lacquer layers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blue paint</td>
<td>Indigo, lapis lazuli</td>
<td>Indigo + lead white</td>
</tr>
<tr>
<td>Red paint</td>
<td>Red lead</td>
<td>Cinnabar</td>
</tr>
<tr>
<td>Yellow/orange paint</td>
<td>Orpiment</td>
<td>Massicot</td>
</tr>
<tr>
<td>Green paint</td>
<td>Indigo + orpiment, malachite</td>
<td>Indigo + Massicot + lead white</td>
</tr>
</tbody>
</table>

Table 1 compares the results of this work (the small painting) with the individual painting depicted on a pasteboard from the 19\(^{th}\) century (the big painting) (Abdel-Ghani 2022). Both paintings were applied on pasteboard supports covered with finer paper sheets, which was made of white pulp in case of the big painting. Both supports were strengthened by adding straw along with human hair in the small painting.

No white ground layer was depicted in either cases. Instead, a lacquer layer was applied under the paint layer in the big painting and a two chrome pigmented under paint in the small painting. Indigo was the only common pigment in both instances. Although it was used mainly in mixtures, which is typical in Persian art, for instance in the big painting, with Massicot and lead white to create green or with lead white to adjust the shade of blue. It was in the small painting as a sole pigment in the blue under paint. Red lead, malachite, orpiment, and lapis lazuli were used in the small painting, in contrast to cinnabar, massicot and indigo in the big painting.

4. THE RESTORATION INTERVENTION

The main aim of the restoration treatment was to stabilize both the pasteboard support and the paint
layers without endangering the fragile and sensitive pigments. The treatment scheme included; Stabilizing and repairing of the paint layer, deacidification of the recto of the support, removing the facing, cleaning and removing the old lacquer, retouching of the paint, application of new varnish. A special handmade acid-free box was made for final protection of the painting in the Museum display.

3.5. Cleaning

Cleaning was performed in two phases; at first, a swab lightly dampened with saliva was applied to the surface in a circular motion (figure 7.a). This process was successful to remove the dirt layer without any effect on the varnish layer or the paint layer below. At this stage, it was possible to discriminate the different colours and to proceed with the sample taking and cleaning process.

As stated by Romão et al., 1990, saliva is one of the most commonly used and most effective water-based cleaning materials. Its efficiency as a cleaning agent credited to the existence of α-amylase, an enzyme that breaks down carbohydrates (Romão et al., 1990). And according to Wolbers, 2000, it contains a variety of constituents including a surfactant, pH buffers, a thickening agent, a chelating agent, enzymes, and antibacterial preservative (Wolbers, 2000).

For the second phase, cleaning spot tests were essential to determine the solubility of unwanted materials and to found the differences between the solubility of the unwanted material and the main paint layer below. It was also important to know which solvents will remove dirt, varnish or overpaint without affecting the paint layer (Rivers and Umney, 2003)

It was shown that toluene and benzene had not affected the shellac layer. On the other hand, dimethylformamide had removed the shellac easily but it could also remove the black outlines over the gilded areas. Alcohol successfully removed the varnish but caused fading of the colour. Isopropyl alcohol was found to be the best solvent to remove shellac varnish without causing any damage to the paint layer.

The labels on the verso and recto sides as well as the red strap of paper adhered to one side and through the thickness of the reverse side were removed with a solution of alcohol and water (1:1). It was used to moisten the adhesive and dissolve it which then removed by scalpel (figure 7.b, c).

3.6. Securing the detached paint layer and splitting paper sheets (consolidation)

The goal of the consolidation treatment is to enhance strength both to the fragile paint layer and to the painting support, sufficient for the painting to endure handling and to tolerate the loads imposed by its structures (Rivers and Umney, 2003). The safe attributes of the consolidate used in this process is essential as it should be prove colour stability, ageing resistance, chemical inactivity, reversibility and satisfactory bonding strength (Zervos and Alexopoulou, 2015).

Klucel G (1%), hydroxypropyl cellulose, dissolved in ethanol and water (1:1) was employed as an adhesive for fixing the separated pasteboard sheets and the loose and fragile paint surface. Injection was employed to ensure deep penetration with the
aid of a hot spatula. The excess of the adhesive was removed using cotton swabs wetted by ethanol (figure 7.d). The consolidated areas were covered with small sand bags over Mylar sheets until drying.

3.7. **Diacidification the recto of the support**

The pH value of the substrate was measured using non-bleeding pH indicator strips. A drop of distilled water was placed on the papier mâché then the pH strip was applied and left for about 3 minutes. The measured pH value was ~ 6. Therefore, deacidification treatment was essential in this case.

Deacidification is a vital chemical stabilization strategy for the acidic paper due to the highly negative effect of acidity on the durability of the paper. The concept of deacidification is focused on removing the soluble acidic content of the paper, neutralizing the residual acidity and depositing a chemical substance into the paper to neutralize the prospective acidity (Blüher and Vogelsanger, 2001; Ahn et al., 2012; Zervos and Alexopoulou, 2015). Non-aqueous deacidification using organic solvents are preferable because they wet paper more rapidly, dry faster from paper than water, have a less swelling effect on the treated paper (Smith, 1971).

In this study, a non-aqueous deacidification treatment was carried out using the alkaline buffer, calcium hydroxide Ca(OH)2, dissolved in an organic solvent, isopropyl alcohol, (Sequeira et al., 2006) (Sequeira et al., 2006). It was applied by spraying to the reverse/recto of the painting, then plotter paper was used to absorb the excess buffering material. Calcium hydroxide was chosen because of its easy application and good effects. It also, according to Kolar, Novak, 1996, has good DP retention after accelerated ageing (Kolar and Novak, 1996).

Prior this treatment, facing the painting was essential to secure the paint layer. Three layers of Japanese tissue paper were adhered to the paint layer using methylcellulose.

![Figure 7. The schematic structure of the foot case cartonnage.](image)

3.8. **Retouching and varnishing**

No filling gaps was performed and a very simple dotting retouching with Acrylic paints was undertaken to enhance the understanding of the painting. Using acrylic paints were confirmed by Umney, 1987 for its ease of use, various colours availability and no special ventilation requirements. In addition, the right patina for the surrounding areas can be reached easily.

Mineral Spirit Acrylic varnish (GOLDEN MSA) was applied as a protective layer with a natural bristle brush. It was highly recommended because
of its desired qualities such as reversibility and ultra violet light endurance. Figure 8 shows the painting before and after conservation treatment.

4. Display
The final stage in the conservation treatment was creating a special case to be utilized in both storage and display of the painting (figure 9). It was made of archival cardboard with a transparent polyethylene window. A stainless steel label was prepared to hold the painting information.

5. Conclusion
A Qajar lacquered painting applied on pasteboard support from the Applied Arts Museum of Helwan University has been investigated and conserved. The conclusion of this study has provided further grasp of the technique, the materials used in this type of paintings and enhanced the fundamental knowledge of conservation treatment that might be followed in similar instances. The analytical instruments operated were Raman microscope and FTIR.

The layered structure of the studied painting revealed its complex structure as the pasteboard support was concealed with a finer quality sheet of paper on which was applied the paint layer. The support was made of rag paper sheets pasted together with animal glue. Shellac resin was used as the lacquer layer. Red lead, indigo, lapis lazuli, orpiment and malachite were the pigments revealed in this study, and were found to be characteristic for the Qajar period and exhibited the common knowledge collected from the previously studied Persian manuscripts and the old treatises.

The conservation treatment comprised; cleaning, consolidation, deacidification, retouching and varnishing. Cleaning the dark lacquer layer was carried out with saliva and Isopropyl alcohol as it was shown that toluene, benzene, ethyl alcohol and dimethylformamide is not appropriate in this case study. However, further research might be needed to establish a concept in this matter. Consolidation was performed with Klucel G 1% dissolved in ethanol and water (1:1) while deacidification was executed with calcium hydroxide, dissolved in isopropyl alcohol. Retouching was applied with acrylic pigments and acrylic varnish was employed for final protection.

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