The retable of the chapel of Our Lady of Mercy in the cloister of Oporto’s Cathedral: study, conservation and restoration

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Abstract: The retable located in the Chapel of Our Lady of Mercy, in the cloisters of Oporto’s cathedral, dates back to the 17th century. Artistically, it belongs to a transition period between the Mannerism and the Baroque styles. The artistic value and the lack of documented information about the artwork led to the development of a project contemplating its the study. Both chemical and physical analyses - observation of the support, micro-FTIR and SEM-EDS - suggest that the retable was carved in sweet chestnut wood, accordingly to the techniques used at the time. The retable presents water-gilded areas contrasting with blue and red phytomorphic motifs. The polychromed areas were later covered with lead white paint. There were also evidences of previous conservation-restoration interventions. The frail condition of the retable’s materials testified the need to conserve and restore it. Among other procedures, the materials were consolidated and the lacunae were filled and inpainted - partially regenerating the artwork’s aesthetic unity.

Keyword: retable, Oporto’s cathedral, 17th century, gilded and painted woodcarving, conservation and restoration

El retablo de la capilla de Nuestra Señora de la Piedad en el claustro de la Catedral de Oporto: estudio, conservación y restauración

Resumen: El retablo de Nuestra Señora de la Piedad se encuentra en la capilla homónima del claustro de la Catedral de Oporto. Creada en el siglo XVII, es una obra de transición estilística entre el Manierismo y el Barroco. El valor patrimonial de la obra y la ausencia de estudios más profundos sobre ella, motivaron su caracterización. Los análisis realizados sobre el retablo (observación del suporte, micro-FTIR y SEM-EDS) permitirán concluir que se trata de una obra de madera de castaño, ejecutado conforme a las técnicas comunes de la época. La pieza presenta zonas de dorado al agua, que contrastan con vestigios de decoraciones fitomorfas en tonos azul y rojo, las cuales fueron posteriormente repolicromadas con blanco de plomo. Existían también evidencias de intervenciones de conservación y restauración anteriores. Conjuntamente, las patologías identificadas demostraron la urgencia de realizar una intervención de conservación – restauración. Entre otros tratamientos se realizó: la consolidación de los materiales presentes, se aplicó pasta de relleno en las lagunas, y se reintegró con color las mismas - devolviendo parte de la integridad estética de la obra.

Palabras clave: retablo, catedral de Oporto, siglo XVII, talla dorada y policromada, conservación y restauración

O retábulo da capela de Nossa Senhora da Piedade no claustro da Sé do Porto: estudo, conservação e restauro

Resumo: O retábulo de Nossa Senhora da Piedade encontra-se na capela homónima no claustro da Sé do Porto. Executada no século XVII, trata-se de um obra de transição estilística entre o Maneirismo e o Barroco. O valor patrimonial da obra e a ausência de estudos mais profundos sobre a mesma, motivaram a necessidade de a caracterizar. As análises realizadas (observação do suporte, micro-FTIR e SEM-EDS) permitiram concluir que se trata de uma obra artística em madeira de castanho, executada segundo as técnicas comuns à época. O retábulo apresenta zonas de douramento a água, que contrastam com os vestígios de decorações fitomórficas em tons de azul e vermelho, os quais foram posteriormente repolicromados a branco de chumbo. Existem também evidências de intervenções de conservação e restauro anteriores. Entre outros tratamentos realizou-se: a consolidação dos materiais presentes, a aplicação de massas de preenchimento nas lacunas e a reintegração cromática das mesmas – devolvendo parcialmente à obra a sua integridade estética.

Palavras-chave: retábulo, Sé do Porto, século XVII, talha dourada e policromada, conservação e restauro

Introduction

The retable of Our Lady of Mercy was executed in the second half of the 17th century, during a transitioning aesthetic period, and shows elements linking it to the Mannerist and Baroque styles (Smith, 1963: 49) [Image 1]. The artwork belongs to the homonymous chapel in Oporto's Cathedral cloisters. The structure has an overall height of 362 cm, 289 cm width and 230 cm depth (from the altar's front to the backof the central niche).

The scarce data available derives from inventories that can be accessed at Sistema de Informação para o Património Arquitectónico - Information System for Architectural Heritage – (SIPA) and Direção Geral do Património Cultural - Directorate-General for Cultural Heritage (DGPC). However, only brief descriptions of the chapel are mentioned in these documents.

As an artistic example of a transitional creative period, the altarpiece is unique, and the oldest artwork in the museum's collection (Museum of Oporto's Cathedral). The retable's materials showed signs of decay, which probably were accelerated by environmental parameters.

An initial observation acknowledged small holes in the wooden support, confirming the presence of wood-boring beetles' activity. Some of the structural elements showed evidence of fungal attack (brown rot) and the presence of salts (partially dissolved in water), which ascended from the granite floor through the wood's capillaries. The polychrome and gilding layers (ground, colour, and Armenian bole) showed accumulated dust on the surface, signs of weakening of the binding medium and abrasive wear. Nearly 45% of the polychrome and gilded areas were affected by lacunae, as a consequence of fracture and detachment, causing visual disturbance.

Figure 1.- The retable in the chapel of Our Lady of Mercy before the conservation treatment. Photographed by Patrícia Monteiro.

Through these lacunae, in the upper section of the altarpiece, red and blue phytomorphic elements, possibly corresponding to the original decoration, became visible.

A shine over the retable's surface evidenced a previous consolidation. In the niches, green layers of paint over the white-coated panels indicated an unsuitable chromatic inpaintintg. Several screws with signs of corrosion fixated the wooden panels and the carved decorative elements.

Documentation from the Direção Regional de Cultura do Norte - Northern Portugal Regional Directorate for Culture (DRCN), was consulted in order to understand the kind of treatments that had been applied during previous interventions: such as in 1999 the conservation and restoration of the altarpiece, followed by the repair of the chapel's roof in 2000. According to information provided by DRCN, the presence of fungi in the wooden support, especially at the back of the altarpiece, motivated these interventions and the placement of an acrylic board partially covering the window behind the central niche (Monteiro, 2015: 46).

A conservation and restoration intervention was planned, based on the condition state and the need to stabilize the altarpiece's fragile materials. The treatments required a better understanding of the historical, artistic, physical and technical aspects concerning the retable of Our Lady of Mercy. Foremost, several samples - from the wooden support, polychrome and gilded areas - were collected, prepared, and observed under a microscope, some of which were subject to micro-FTIR and SEM-EDS analysis. Final results were compared to similar studies. The environment was also evaluated, considering humidity and temperature values and fluctuations. Sharp changes of humidity, registered inside the chapel, had a direct influence on the materials stability. Tests were performed *in loco* with conservation materials, to determine their adequacy for the necessary treatments.

History and artistic style

The chapel of Our Lady of Mercy was first named in honour of Saint Catherine in the 17th century (Afonso et al, 2005) and at the time it was used for funerary and devotional purposes (Pereira, 1995, vol. I, p. 386). The blue and white tile panels (1738), made by António Vital Rifarto (Gonçalves, 1972: 262), represent Saint Catherine of Alexandria on the right side and possibly Saint Cajetan on the opposing wall. During the altarpiece's disassembling it was possible to identify traces of a mural painting behind the wooden structure (Monteiro, 2015: 6-7). On the central niche of the retable lays a sculpture of Our Lady of Mercy (dated between late 18th and early 19th centuries); on the right niche the sculpture of Saint Catherine of Alexandria – possibly dating from the 17th century (Monteiro, 2015: 9) – and on the left niche the sculpture of Saint Cajetan's – probably made in 1682 and originally placed at the retable of Saint Apollonia, in the body of Oporto's Cathedral (Ferreira-Alves, 1989: 49-50).

Also relevant to this case study was the fact that this retable is aesthetically similar to the ones described in the 1682 contracts for the execution of several altarpieces for Oporto's Cathedral. These retables were carved by Domingos Nunes and António Nunes, and painted and gilded by Manuel Ferreira (Brandão, 1984: 558-561).

This altarpiece is an example of the Renaissance-inspired movement in Portuguese woodcarving that spans through all the 17th century (Smith, 1963: 49) characterized by its robust quality, vegetalist and animal woodcarved motifs, as well as the preference for sculpture over painting (Smith, 1963: 50). These same characteristics can be seen in the retables ordered in 1682 (Brandão, 1984: 558-561). Artistically, this work shows decorative elements from both the Mannerism period (lines of pearls and pilasters) and the Baroque period – woodcarving work on the predella and the corbels.

The structure is divided into three vertical parts and one horizontal body – a typology commonly associated to the 17th century's aesthetics (Lameira, 2005: 31). The influence of Serlio's mannerist elements – present in Portuguese architecture since the mid-16th century (Smith, 1963: 50-51) – may be seen in the pilasters with vertical ornaments, the division of niches, the existence of panels and the formation of an arch in the upper structure. However, the woodcarving work on the corbels and the predella, along with the dynamism of the polygonal floor plan, indicate a transitional and transforming style pointing towards the Baroque.

The base wood panels, that cover the granite block, correspond to new elements probably placed in the 19th century.

Diagnosis

Environmental conditions are not the most suited for the conservation of the materials that compose the retable. Two of the chapel's walls are facing the exterior, and there is a non-sealed window behind the main niche. To confirm and study the chapel's environmental conditions measurements were taken (with a Greutor's thermometer and hygrometer). The results confirmed high levels of relative humidity with daily changes. A significant difference (approximately 7%) was registered between the backside (close to the window) and the front part of the altarpiece. Humidity values were as high as 95%, in the back, and 92%, in the front, with drops as drastically as 26% (consecutive days) (Monteiro, 2015: 53-57).

In the wooden support rottenness due to fungi was detected on the uncoated elements in contact with the granite floor (antependium's flanks lower half). Humidity and temperature conditions may have potentiated their development. Salts partially dissolved in water, ascended from the granite floor through the wood's capillaries (Blanchette, 1998: 55-68), forming crystals in this structural elements. The visible crevices and fissures resulted from both the hygroscopic and anisotropic properties of the wood. Some of the decorative elements were missing, such as several winged angels in the entablature. Only two remain, one on the left side of the entablature and other on the predella. The iron nails, that reinforced the wooden structure and held the decorative elements, showed active corrosion, and were too weak to fulfil their original function (Monteiro, 2015: 39-42).

The frontal surface (polychrome and gilded areas) was covered in dust, dripping stains and revealed general wear. As polychrome and gilding layers do not contract and expand as the wooden support (Dardes *et al*., 1995: 3), fissures, cracks, and detachments occur. The humidity and temperature fluctuation felt in the chapel influenced these movements. However, the conservation condition of the ground and paint layers is also relevant. In this case, the ground layer and the bole exhibited pulverulence, due to deterioration of the protein-base binding medium (Rachwal *et al*., 2012: 474-481). These facts combined originated the numerous gaps.

Through an initial observation, it became apparent that the altarpiece had been under various conservation and restoration treatments. The wooden support showed evidence of woodworm beetles' activity (inactive), different wood and paper fillings, a surface coat and several nickel screws. Under the central part of the altarpiece, between the artwork and the granite block, a wooden structure covered with a hydrophobic substance had been placed; a final gloss coating was applied to the surface of the altarpiece, and the niches had an inadequate greenish inpainting. It was determined that the detaching filling materials, the rusty nickel screws, the visually disquieting inpaintings, and the unevenly applied final coat should be removed.

The documents consulted had no specific information on the retable of Our Lady of Mercy. The urge to preserve it (through a conservation and restoration intervention), and the interest in characterizing such a unique altarpiece, justified a material and technical analysis. Through these studies, we intended to determine what was the initial appearance of the retable, the layers applied afterwards and to identify the conservation materials used.

Experimental

For the non-invasive analysis, visible spectrum photography (using a Digital Single-Lens Reflex *Nikon D3000*) allowed the creation of photogrammetry models using *Autodesk 123D Catch*. Also, based on observation of the retable's structure, several schematic drawings were designed using Adobe Photoshop CS5 culminating in an animated 3D model of the construction process (Autodesk Maya).

To identify the support's wood, eight samples (1cm3) were collected from the front and the back, four from each side. These samples were analysed under a digital microscope, Dino-Lite AM 4113T®. The areas selected for sampling took into consideration the location, the wooden element's position and condition state. All samples had similar macroscopic characteristics except one specimen from Saint Catherine's niche.

A total of twenty-two micro samples from the polychrome and gilded areas were mounted in acrylic resin as cross sections. The sampling included micro-specimen from white areas (ten samples), gilded surfaces (eight samples), flesh tones (two specimens) and hair (two samples) of two winged angels. The samples were collected considering the location, the colour differences, the painting methods, the number of layers present, and the decay condition. Based on a first observation, it seemed that only the white areas were coated with new paint layers.

These cross sections were analysed through *Optical Microscopy* (OM), Fourier Transform Infrared microspectroscopy (micro-FTIR) and *Scanning Electron Microscopy with Energy Dispersive X-ray spectroscopy* (SEM-EDS). A binocular BX41 Olympus microscope (correct to the infinite and coupled with a digital camera using P*roRes Capture Pro 2.7* software) was used for the observation and characterization of the cross sections. For the identification of the binding media and selected pigments and materials used in previous interventions, a *Thermo Nicolet's Continuum* infrared microscope coupled with an *IV Nexus 670 FTIR* (also from *Thermo Nicolet*) spectrometer was employed. Spectrums were acquired in transmission mode with diamond cell compression (between 4000-650cm-1), 256 scans and a spectral resolution of 4cm-1. SEM-EDS analysis was fundamental for pigment identification and for the characterization of the gold alloy and the layer granulometry. A 3*700N HITACHI* microscope with a *Bruker Xflash 5010* X-ray spectrometer and a *Silicon Drift Detector* (SDD) *Xflash 5010* were used. All analyses were performed under high vacuum with a tension of 20 kV.

Results

The retable of Our Lady of Mercy, material and technically, corresponds to the practices enforced at the time of its conception.

The constructive system is based on a polygonal plant set away from the end wall. A base structure, with arches and pillars, acts as a support for the multiple wooden panels [Image 2]. These are assembled by butt joints, possibly with protein glue, and reinforced by small wooden pieces nailed at the back (Vivancos Ramón et al., 2006: 93), without fittings. On the base, a granite block (Guerra-Librero, 2006: 9) supports the structure's weight. Horizontally, two beams connect the altarpiece to the end wall of the chapel. The retable was built from the bottom up, and from the centre to the exterior. However, observing the backside, it is clear that not all the elements are placed in their original position. Some of them have been moved and relocated according to their present shape, and this is particularly clear in the attic. We can assume that the structure was partially or entirely disassembled in a previous intervention.

Through the various analysis, studies and observation it became possible to identify the materials used in the execution process of Our Lady of Mercy's retable.

Figure 2.- Three-dimensional model representing the construction process of the retable. Created with the software Autodesk Maya; a) Arches' placing; b) Wooden boards nailed from the centre out; c) Wood structure's final appearance. 3D modelling by Patrícia Monteiro.

The 17th century altarpiece consists of a chestnut wood support, carved and prepared for painting and gilding. A ground layer, made of gypsum ($CaSO_4.2H_2O$) and protein glue, covers the entire surface. A thin layer of fine Armenian bole with protein glue (between 22µm and 20µm) was applied over the preparation layer. In the gilded areas, this layer is thicker and in most samples the size doubles.

The flesh tones of the angels' face were achieved with a layer of vermillion (HgS), and lead white ($2PbCO_3.Pb(OH)_2$), mixed in oil.

The niches (side and central), the attic and the hair of the winged angels were covered with a new ground layer of calcium carbonate ($CaCO_3$) and protein glue. These areas received then a paint layer: in the angels' hair, a layer of a brown ochre with oil; in the niches and the attic, a coat of lead white and oil - in some samples also with a yellow ochre pigment. Over the attic, phytomorphic elements in red and blue ornamented the altarpiece. Considering the piece's artistic period, the blue tonality was expected to be either azurite or Prussian blue. However, the SEM-EDS results showed no evidence of any of these pigments. In fact, there were no blue particles in the sample's layer that could justify this blue tonality on the surface. An answer could be a blue dye, which is difficult to identify through micro-FTIR and SEM-EDS analysis

The remaining surface (woodcarved) was water gilded, with the application of a gold leaf – a 23 karats gold-silver-copper alloy possibly polished [Image 3].

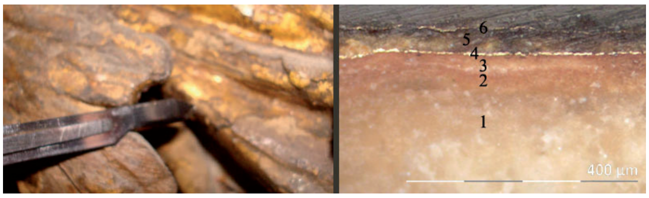

Figure 3.- a) Sample collected in the gilded predella; b) Cross-section (scale 400µm). Identification of two gold layers (number 4 and 6). Photograph and image acquisition by Patrícia Monteiro.

It is possible to identify a second stage, when another calcium carbonate ground layer was applied to the niches, attic, and retable's sides and worked as a base for the new paint layer. In the case of the retable's lateral, small phytomorphic elements were drawn, possibly with carbon black. In the niches and the attic, a preference for lead white and oil layer remained, and a new coat was applied. The face of the winged angel in the predella was painted (over the original colour), but in this case with lead white and red lead (Pb_3O_4) bound in oil. Also in this area there are evidences of a re-gilding process; a 22 karats gold leaf (Au 93%, Ag 5%, Cu 2%) was applied over a red iron oxide pigment, red lead and oil - mordant technique [Image 3].

The niches surface was overpainted with a lead white lead oil paint applied over a new calcium carbonate ground layer.

Currently, it is possible to see the contrast between the white areas and the remaining original woodcarved and gilded parts. However, we could not determine when most of the non-original layers were employed, with the exception of a white layer in Saint Cajetan's niche and the central niches. The samples from these areas presented a final layer of lead white mixed with barium sulphate, possibly used as an extensor [Image 4]. Since the use of barium sulphate as an extensor began during the 19th century (Feller ed., 1986: 49), it is likely that this intervention dates after 1800. All the wooden panels in the antependium and base are also from the 19th century.

The application of these new ground and paint layers must have been related to the decay of the original ones (with visible lacunae), but also with a possible change of artistic and aesthetic taste. Due to the complexity of the sample's stratigraphy all analytical results are summarised in table 1.

It is difficult to fully understand the chromatic alteration applied over the retable's surface. All samples presented a gypsum ground layer and an Armenian bole layer. This last layer is thicker in the wood carved areas, clarifying the will to gild them.

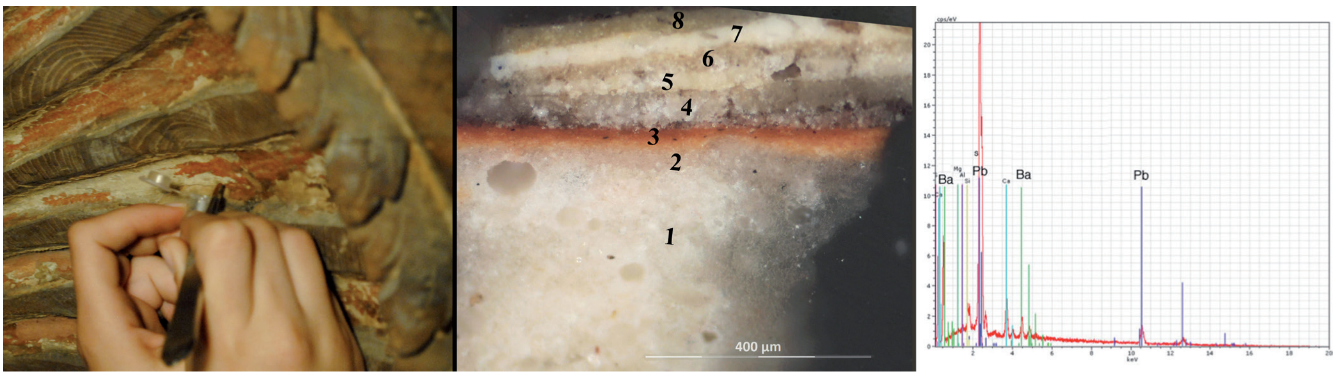

Figure 1.- a) Sample collected in Saint Cajetan's niche; b) Cross-section (scale 400µm). Original layers: 1 to 3,;new ground layers: 4 and 6; new white paint layers: 5 and 7; c) EDS spectrum of layer number 7: identification of Pb and Ba. Photograph, image acquisition and graphic by Patrícia Monteiro.

Table 1.- Results of the analytical study of the original materials: support, polychrome and gilded layers.

AREA	SAMPLES	FUNCTION	EXAM	ELEMENTS/ COMPOUNDS	RESULTS
Wooden structure	Four from the back and four from the front	Support	Observation of physical characteristics	-	*Castanea Sativa* (chestnut wood)
On the surface of the support	Wooden support, polychromy and gilded samples	Isolation layer over the wooden support	-	-	*Not identified*
Over the retable's front	Thirteen samples from the polychrome and gilded areas	Ground layer (white)	micro- FTIR	Calcium sulphate dehydrate, calcium carbonate, oxalates and protein-base glue	Gypsum, Calcium Oxalates and Calcium Carbonate
			SEM-EDS	Ca and S (indicates the presence of calcium sulphate)	
Over the ground layer	Eighteen samples from polychrome and gilded areas	Bole (orange/red)	micro-FTIR	Kaolinite and protein material	Clay (Armenian bole) and protein-based glue
			SEM-EDS	Si and Al (indicates the presence of silicates) and Fe (indicates the presence of iron oxide)	
In the gilded areas (over the bole layer)	Six samples from gilded areas	Gold leaf	micro-FTIR	-	-
			SEM-EDS	Au, Ag and Cu (96%, 3% and 1%)	Gold alloy (23 karats)
In the angel's face, entablature	One sample	Flesh tone paint layer	micro-FTIR	Kaolinite (suggests the use of earth pigments), lead white, metal carboxilates and oil	Lead white, vermillion, red ochre, and oil
			SEM-EDS	Pb, S and Hg	
In the angel's face, predella.	One sample	Flesh tone layer	micro-FTIR	Kaolinite (suggests the use of earth pigments), lead white, metal carboxilates, and oil	Lead white, vermillion, red ochre, and oil
			SEM-EDS	Pb, S and Hg	
		New flesh tone layer	micro-FTIR	Kaolinite, lead white, metal carboxilates, and oil	Lead white and oil with red ochre and read lead
			SEM-EDS	Fe, Si, and Al (possibly related to silicates and iron oxides), and Mn Pb (orange grains)	

In the angels' hair, entablature and predella	Two samples	White paint layer	micro-FTIR	Lead white (cerussite and hydrocerussite) and oil	Lead white and oil
			SEM-EDS	-	-
		Brown paint layer	micro-FTIR	Kaolinite (suggests the use of earth pigments) and oil	Brown ochre and oil
			SEM-EDS	-	-
Over the attic's bole layer – blue decorative motives	One sample	New ground layer	micro-FTIR	-	-
			SEM-EDS	-	-
		White paint layer	micro-FTIR	-	-
			SEM-EDS	Pb, Ca, Si, Al, and C	Lead white, with carbon black grains, and oil
		Dark blue paint layer	micro-FTIR	-	
			SEM-EDS	Cu, Si, Ca, Na and Fe	Possibly azurite (but with no visible blue grains), natural blue ultramarine (but the levels of Al were too low), or Prussia blue (not easily detected through SEM-EDS, Fe pick difficult to detect)
		New preparation layer	micro-FTIR	-	-
			SEM-EDS	Ca and S (indicates the presence of calcium sulphate)	Gypsum
Over the attic's bole layer – white panel	One sample	Two new preparation layer	micro-FTIR	Calcium sulphate dehydrate, lead white, metal carboxalates and oil	Gypsum with trace elements of lead white and oil
			SEM-EDS	-	-
		Two white paint layer	micro-FTIR	Silicates, oxalates, lead white, metal carboxalates, and oil	Lead white and oil
			SEM-EDS	-	-

Over the bole layer in Saint Cajetan's niche	One sample	New ground layer	micro-FTIR	Calcium carbonate	Calcium carbonate
			SEM-EDS	Ca	
		White paint layer	micro-FTIR	Lead white, metal carboxilates and oil	Lead white and oil
			SEM-EDS	Pb	
		New ground layer	micro-FTIR	Calcium carbonate	Calcium carbonate
			SEM-EDS	Ca and Pb (traces)	
		White paint layer	micro-FTIR	Lead white, calcium carbonate (used as a pigment or contamination from the under layer), and oil	Lead white, barium sulphate, and oil
			SEM-EDS	Pb, Ca (traces), and Ba	
		White layer	micro-FTIR	Calcium carbonate, possibly protein-material and silicates	Possibly a new preparation layer with calcium carbonate and protein-based glue
			SEM-EDS	Ca	

However, it seems odd that a red-orange bole layer should be applied to the retable's front, to then be covered with a new ground layer, preparing the surface for a white/yellow iron oxide paint layer. Hypothetically, this could prove that the initial intention was to entirely gild the retable, and then paint the decorative motifs on the non-carved areas (as indicated by the red and blue elements on the attic). However, none of the samples collected from the polychrome layers presented evidence of gold leaf.

When observing the numerous alterations applied over the Armenian bole on the niches and attic, the samples' stratigraphy becomes even more complex, showing various layers with different thicknesses, density, grain, colour, and function.

The new ground layer, made of calcium carbonate (over the bole), was covered with a lead white lead/yellow ochre layer. Afterward, probably due to decay, another sequence of ground layer and paint, made of lead white lead and oil, was applied. The red and blue decorative motifs in the attic were covered with a ground and paint layers, either to hide signs of decay or merely to change the retable's aesthetic appearance.

The materials in the gilded areas seem to be original, except for the predella, where a sample evidenced a re-gilding with mordant over the previous gold leaf.

Only the barium sulphate and lead white lead layers, in the central niche and Saint Cajetan's niche, can be chronologically placed after the 19th century.

Further materials, used in recent interventions, were also identified through the analytical techniques. Among them, wax and an acrylic resin - ethyl acrylate-methyl methacrylate copolymer (Paraloid B72) - , were detected. The support showed evidence of a consolidation process (potentially with the aforementioned acrylic resin), the substitution of wooden decorative and structural elements, the placement of a wooden structure coated with an hydrophobic material over the granite stone block, the use of nickel screws (with greenish oxidation) for structural reinforcement and the filling of gaps with a paper paste. Some of these gaps in Saint Catherine and Saint Cajetan's niches showed further chromatic reintegration in shades of green, discordant with the surrounding white coloration areas. It is possible that these materials were applied during the 1999's conservation and restoration intervention.

Conservation treatment

The conservation plan considered both the recorded environmental thermo-hygrometric values and the nature of the materials that composed the retable. The purpose was to stabilize the retable's materials decay and comprehend what factors were contributing to those processes. The number of lacunae was visually interfering, so a solution was needed in order to create a sense of unity.

The altarpiece was exposed to humidity values as high as 95% in the front and 92% in the back. Lower humidity values were also verified, 37% in the front and 41% in the back. In terms of the temperature values, records showed between 23,5ºc and 12,5 ºC in the front, and 23,4 ºC and 12 ºC in the back.

Test samples were prepared in order to select the materials that could sustain the stability and efficiency of the intervention. Several consolidation adhesives were tested, such as a protein-based glue (5% concentration solution of rabbit-skin glue and distilled water), a 25% solution of polyvinyl acetate adhesive, PVAc, with distilled water (surfactant applied previously, ethanol 96%,), and an acrylic resin (Paraloid® B72) in aliphatic hydrocarbons (Shellsol® A) solution at 10%. The best result was obtained with the 25% PVAc solution showing good penetration and consolidation of the polychromy and gilded layers.

To determine the most accurate solution for dust and dirt removal, pH and conductivity values were measured. The pH values were between 5,4 and 6,9 and the average salts' concentration was 80,3µS/cm (lowest value 11µS/cm, as high as 1660µS/cm, on a total of 43 point measure).

Several buffered aqueous solutions (1% acetic acid and triethanolamine), with different pH levels, and an aqueous solution with a chelating agent (1% trisodium citrate) were prepared and tested. The chelating agent in this last solution helped to dissolve the metal complexes of the surface (Wolbers, 2000: 109), showing better results during preliminary cleaning tests. For the removal of acrylic resin deposits, organic solvent tests were undertaken. The best result was obtained with the use of an undiluted aliphatic hydrocarbon, Shellsol® A.

In order to attenuate the discrepancy between the humidity levels registered between the front and backside of the retable, a mobile polyethylene foam tube was fixed around the acrylic board placed to cover the window behind the central niche.

After the aforementioned stages, the polychrome and the gilded layers in risk of detachment were consolidated, using a polyvinyl adhesive (PVAc) diluted at 25% in distilled water. A surfactant (ethanol 96%) was applied previously in order to reduce the surface tension.

After this process, the wooden structure was partially disassembled, so that all structural elements could be treated. The access to the back area allowed the mechanical cleaning of the surface (with brush and vacuum cleaner) and the preventive disinfestation and disinfection of the support, using permethrin in saturated hydrocarbons solution both in liquid (Xylophene®) and gel forms (Xilix Gel®).

The most fragile areas of the support, both in the front and back, were consolidated with an acrylic resin (10% of Paraloid® B67) diluted in both aromatic and saturated hydrocarbons solvents (75% of Shellsol® D40 and 15% of Shellsol® A).

Some areas in the antependium presented decay, as mentioned. The two wooden elements that supported the antependium's flanks were weakened by the action of fungi and therefore couldn't fulfil their original function. They were replaced by two new chestnut elements, cut and then coated with a two-component epoxy resin for protection (Sikadur® 52 Injection). Other areas of the antependium's panel exhibited cavities, a consequence of woodworm beetles' activity, which made the material more fragile. To reinforce the panels, the gaps were filled with a paste made of epoxy resin and phenolic microspheres (Araldite® 427 HV e SV). There were also two gaps (8cm each approximately) on the lower part of the antependium's side panels, so two chestnut wood elements were cut and glued, with PVAc, to complete the original.

The metallic elements that still assured their original role were cleaned of corrosion, coated in a solution of 10% tannic acid with distilled water and 96% ethanol, and protected with a layer of 20% acrylic resin (Paraloid® B72) diluted in acetone.

Concerning the retable's structural unions different treatments were applied. Stainless steel screws replaced the metallic elements that no longer fulfilled their function in the structural unions. In the decorative motifs, deteriorated screws and nails were replaced with beech wood (Fagus L.) dowels, and glued together with PVAc.

The dust from the front of the altarpiece was removed using a brush and a vacuum cleaner. A solution of 1% chelating agent (trisodium citrate) diluted in distilled water solution allowed for the removal of both adhered dirt and water dripping stains coming from the roof.

To remove the inappropriate chromatic reintegration and the acrylic resin deposits, from previous interventions [Image 5], various solvents were used, such as Shellsol® A, Shellsol® D40, 96% ethanol.

Figure 5.- Removal of the acrylic resin using both saturated and aromatic hydrocarbon solvents. Photographed by Patrícia Monteiro.

An acrylic resin (5% Paraloid® B72 in Shellsol® A) protective coat was applied to separate the polychrome surface from the filling paste used to fill all the gaps: calcium carbonate, barium sulfate, and vinyl adhesive (white Modostuc®).

Following these procedures, it was necessary to integrate the filling pastes according to the enveloping chromatic tonalities [Image 6]. These aesthetic interventions intended to reduce the visual disturbance caused by lacunae in the white areas and the antependium's front, as well as to conceal the filling materials applied on the wooden support. It was a conscience choice to preserve all polychrome layers, as they testify the alterations undertaken through the years.

The techniques chosen for the inpainting considered the unique characteristics of each chromatic area.

The filling materials on the white areas' lacunae were concealed using both the trattegio and the chromatic selection. The combination of both techniques consists in the application of vertical lines - overlapped and juxtaposed - over a base ton (Bailão, 2011: 55). The pigments (Sennelier® and Kremer®) were agglutinated in an acrylic medium (Liquitex® Glazing Medium), and mixed directly on the palette. Through these two techniques combined, it was possible to achieve a chromatic vibration, colour depth, and saturation similar to the original, but still distinguish the intervened areas [Image 6].

Figure 6.- Central niche during chromatic integration with acrylic paint of the filling paste. Photographed by Patrícia Monteiro.

The filling materials employed in the antependium's polychromy lacunae were retouched with a sub-tone technique, using gouache (Winsor & Newton®) to equal the saturation and opacity of the original paint.

For that same reason, the fillings in the support were inpainted also with gouache (Winsor & Newton®), using a mimetic technique. It is possible to identify these filled areas as they reflect light differently from real wood.

Finally, the surface sheen was corrected by applying a new layer of the previously mentioned protection coat composed of acrylic resin dissolved in a saturated hydrocarbon solvent (5% Paraloid® B72 in Shellsol® A) [Image 7].

Figure 7.- The retable of Our Lady of Mercy after the conservation treatment. Photographed by Patrícia Monteiro

Preventive supervision and maintenance of the space were advised to avoid future alterations. New decay evidence may develop and should be identified and contained as early as possible, considering the humidity values and fluctuations felt in the chapel. Reinforcement of the chapel's surveillance was recommended, as its collection is accessible to acts of vandalism. In parallel, the artistic pieces on display in the Gothic cloister lack information *in situ*. It is therefore pertinent, to include further informative elements that allow visitors to understand the religious and cultural importance of these collections (Monteiro, 2015: 90-91).

Final Remarks

This study deepened the knowledge available on the retable of Our Lady of Mercy and consequently of the Oporto Cathedral. It also allowed the preservation of an important cultural asset representative of a transitional aesthetic period.

From a physical and technical standpoint, the altarpiece is consistent with the artistic practices developed during the second half of the 17th century in northern Portugal. The original altarpiece consists of a chestnut wooden support, with reinforced basic joints that sustain the structures' weight. The wooden surface was cover with a calcium sulphate (gypsum) and protein glue based ground layer and an Armenian bole layer. The wood carved areas were water gilded with a high-quality gold alloy leaf (23 karats). The polychrome areas present evidence of phytomorphic decorative elements painted with different pigments.

In the course of time, a new carbonate sulphate ground coated the original decorative motifs, followed by a colour layer (lead white and yellow ochre). The process repeats itself in some parts of the retable, as the sample's cross-section show. The face of the winged angel in the predella was also repainted, possibly due to lacunae on the original paint layers. A sample from the predella's gilding showed the application of a new bole layer (red ochre and red lead pigments) and gold leaf (oil gilding).

It is not possible to date all thealterations of the polychromy, however, the presence of a layer with lead white and barium sulphate, in Saint Cajetan's niche and in the central niche, as correspondence with an artistic practice that begun in the 19th century.

According to the DRCN's reports, the visible alterations are related to restoration treatments in the 20th century. Among them, the wooden support and paint layers' consolidation, the application of gap filling materials, the chromatic inpainting of the two niches and the structural reinforcement of joints with screws.

The conservation treatment allowed to stabilize the decay of the retable's materials, to restore its aesthetic dimension in the white areas and to introduce a solution for the abrupt humidity variations. Likewise, through the disassembly of part of the structure, a careful observation of the fittings and fixating elements facilitated the characterization of the building system.

The material and technical studies that were undertaken during the conservation and restoration treatment, represent a valuable contribution to the knowledge of Portuguese retables', as it adds information on this unique altarpiece. Similar studies of other Portuguese altarpieces will be necessary to better understand their structural and material evolution. The results may then be compared to determine common practices and singularities.

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