*European Journal of Science and Theology,* April 2017, Vol.13, No.2, 13-24

# SCIENTIFIC INVESTIGATION FOR A POSSIBLE CONSERVATION PROJECT OF THE WOODEN DOOR OF THE BREGNO'S AEDICULA

**Federica Balletti[1*], Angela Lo Monaco[1], Giorgia Agresti[2], Luca Calienno[1] and Claudia Pelosi[2]**

[1]*University of Tuscia, Department of Agricultural and Forestry Sciences, 01100 Viterbo,*
[2]*University of Tuscia, Department of Economics and Management, 01100, Viterbo, Italy*

(Received 22 September 2016, revised 11 October 2016)

## Abstract

The Basilica of Madonna della Quercia (Viterbo, Italy) houses an important heritage constituted of wood and marble artefacts, paintings, statues, books and sacred paraments that can be dated back in a wide period ranging between the beginnings of the sixteenth century to the present time. These artefacts constitute a relevant cultural resource for the parishioners and must be considered especially for their religious and demo ethno anthropological significance. For this reason, these objects must be correctly preserved in order to ensure their transmission to future generations. Specifically, this paper focuses the attention on the door of the Bregno's aedicula. This door can be considered a polymateric artefact of wood and painted gilded plaster.
The door was carefully investigated in situ to gather information on the construction technique and some samples were obtained for laboratory analysis aimed to characterize the constituent materials.

*Keywords:* demo ethno, anthropological heritage, preservation, optical microscopy, spectroscopic techniques

## 1. Introduction

The study and diagnosis of polychrome artefacts generally starts from the investigation of the exterior surface, as part of the artwork containing information about its history, possible previous interventions, as well as about the conservation status [1-3].

The first and most stable material for creating precious objects or gilded surfaces was gold. The gilding technique consists on applying a gold leaf to a previously treated wood surface. Italy is a country rich of gilded artworks. This technique was introduced in our country in the middle age and was widespread until the late Baroque [4]. Gold was privileged for its properties: golden shine and glitter, resistance to corrosion (gold is the most electronegative transitional

[*]E-mail: federica.balletti@unitus.it, tel.: +390761357991

element, therefore 'noble') and rarity. Its face-centred cubic crystal structure makes it soft and ductile; this characteristic, together with gold chemical stability, led to the use of leaf and powder to cover various objects [5]. As far as the liturgical wooden objects, the 'gilding' technique was applied in gilded sculptures and altarpieces, icons, frameworks, and furniture. Over time, these objects have been the subject of various interventions and in many cases the original golden layers have been lost or replaced with more economical imitations [6].

The characterization of materials in artistic gilded objects is important for establishing the composition, structure, morphological and physical–chemical parameters useful for monitoring the conservation state, the behaviour and the evolution during time of their aging/degradation/deterioration processes.

Materials characterization is also useful to evaluate the influence of previous restoration treatments (cleaning, consolidation, retouching, varnishing) on the conservation state of the original materials and also for a rationale choice of methods and materials of intervention, compatible with the original ones.

The structure and morphology of gilded surfaces can be more or less complex according to the materials used, to the supports (wood, stone, metal, glass, paper, parchment, etc.), and to the requirements of the purchasers or to the artistic style of a particular historical period. During the centuries, the use of precious metal leafs and powders (mainly gold but also alloys of gold with silver and copper) was substituted by imitations of gold leaf (made of Cu and Zn; Ag, Cu and Zn, etc.). In this way, the cost for gilding was considerably reduced, allowing a large-scale decoration of artefacts.

The conservation-restoration activity and conservation science are useful to complete the knowledge of this evolution, but also to better understand all factors and mechanisms that assured the survival of the 'gilding' coatings over time, offering tangible proofs of the composition, meaning, value and processes lying behind these techniques [6].

According to some reports the gilding on wood was performed by applying different preparatory layers [7]. The first layer generally consists of animal glue. The second setting layer was a mixture of glue and gypsum or calcite, depending on the availability of the materials. In fact, while in the countries of Northern Europe generally calcite was used, in the Southern countries gypsum was more common. The third layer was formed by bole or animal glue, kaolin and iron oxide. The way in which the gold leaf was made to adhere to the bole, differentiated between the oil gilding and water gilding. In oil gilding, the leaf was applied above the bole by the use of adhesives or mordant. On the other hand, water gilding was performed by applying an aqueous mixture over the bole in order to improve the adhesion of the gold leaf.

The gilding techniques, based on pure gold foil or powder, required a rather expensive material and had to be used only for decorations having high value. In many cases, economic reasons and the need for simplified application techniques led the artisans to their own research into the so-called 'false gilding', which imitates the gold using other metal materials. Tin or silver sheets are common examples of 'false gilding', which could also be produced by means of powder or metal flake materials. Unfortunately, the silver is found to be particularly susceptible to degradation, which consists mainly in the formation of dark surface oxidation products [8].

An important gold substitute, used by artists from different cultures since the middle ages, is arsenic-based yellow pigments, in particular orpiment. This mineral pigment was first used on oil paintings to give light on curtains, brocade, still-life elements (such as fruit and flowers) [9].

In the 17$^{th}$ and 18$^{th}$ centuries, orpiment was not used in the paintings, with the exception of still-life, but more frequently in historical and interior furniture. During the 19$^{th}$ century, arsenic pigments were gradually replaced by new synthetic compounds, such as chrome yellow, also in order to avoid the use of traditional but toxic pigments [9].

Due to the brightness and splendour of gilded decorations, most relevant works, based on gilded wood, can be found in religious monuments, such as churches.

An important example of these works is the polymateric door that closed the marble aedicule (dated to 1490), made by Andrea Bregno, artist and architect of the Italian Renaissance (Figure 1). The altar represents one of the most valuable objects stored in the Basilica of *Madonna della Quercia* (Viterbo, Italy) [10; Archivio Storico Madonna della Quercia, vol. 113 c.59v and vol. 115 c.142v]. The aedicule (Figure 2) is located at the end of the central nave of the presbytery and contains a miraculous tile with the Madonna and Child painted by Master Monetto in 1417 [10, p. 397; Archivio Storico Madonna della Quercia, vol. 113 c.59v and vol. 115 c.142v].

The history of the door is not well known. The study of the documentary sources allowed for obtaining only some information on the probable origin of the gilded wooden door. In particular, on September 24$^{th}$ 1630, a silver door, made in Naples, was donated to the Basilica by the Prince Francesco Peretti Montalto [10, p. 446; Archivio Storico Madonna della Quercia, vol. 113 c.59v and vol. 115 c.142v]. According to this documentary source, the cost of this door exceeded 1,000 *scudi*. The door, now stored in the Basilica's museum, is made of wood and gilded stucco so, the original silver door was probably substituted, but we have not certain information on this event. Some hypotheses have been proposed, the first one is that the silver door was offered in 1789, together with the treasure of the Basilica of *Madonna della Quercia*, to Napoleon for saving the Vatican States, and the Pope Pio VI, to be taken prisoner by Napoleon [Archivio Storico Madonna della Quercia, vol. 113 c.59v and vol. 115 c.142v; 10, vol. II, p. 168]. On that occasion, it has been hypothesized the creation of the beautiful wooden copy.

The second possibility is that the original door was sold in 1862-1884 to support the high costs for the celebration of the 4$^{th}$ centenary of the *Madonna della Quercia*.

Lastly, it can be supposed that the wooden door could be original and so dated back to 1630, even if this hypothesis seems quite unlikely.

**Figure 1.** Front and back side of the door.

**Figure 2.** *Aedicula* made by Andrea Bregno.

In 1959, on the occasion of the celebration for the *Madonna della Quercia*, the gilded wooden door was substituted by a new silver door made by the Viterbo goldsmith Lorenzo Pinzi [10, p. 283; Archivio Storico Madonna della Quercia, vol. 113 c.59v and vol. 115 c.142v]. Nowadays, this new door closes the sacred icon painted on the terracotta tile that shows the coronation of the Virgin Mary. The aedicule, in the Basilica of *Madonna della Quercia*, assumed during the centuries a double function: to protect the sacred icon of the Virgin and also to have devotional significance for the parishioners. As a consequence, the door served as barrier protection for the icon but it also had a symbolic significance. In fact, as can be derived from the literary sources, the door was generally closed, even during the Eucharistic celebrations, in order to avoid distraction of the faithful. The door was opened only during the festivity for *Madonna della Quercia* celebration [10; 10, vol. II, p. 168; Archivio Storico Madonna della Quercia, vol. 113 c.59v and vol. 115 c.142v]. Differently, today the door is always open in order to allow the parishioners for accessing and visiting the *aedicula*.

In this paper, the attention will be focused on the gilded and painted wooden door that at present is preserved in the little museum created inside the Basilica to store sacred objects and artworks. Following a methodological work previously consolidated, the door was carefully examined by in situ inspection in order to gather information on the construction technique and to address the sampling points for laboratory analysis [11, 12].

The choice of the samples was made taking into account both the laboratory technique requirements and the respect of the work of art [13, 14].

Micro-structural and technical aspects on gilded layers can be understood through non-invasive and micro-destructive analytical techniques [6].

In this work samples were analysed by optical microscopy, for wood species identification, and by spectroscopic techniques in order to characterize the materials of painted and gilded stucco.

## 2. Experimental

A first step of the investigation was devoted to the *in situ* inspection of the door. This step was relevant for the study of the construction technique, of the different parts and materials, and for choosing the sampling points for laboratory analysis [13]. Painted and gilded surface was examined also by X-ray fluorescence (XRF) spectroscopy in order to detect the chemical elements. The XRF analysis was carried out by a portable instrument equipped with a 5-50kV tube and a Si-PIN detector (resolution 155 eV at 5.9 keV). A Surface Monitor II (Assing®) was used equipped with Ag anode operating at 40 kV and 75 μA.
*In situ* inspection was carried out by simple magnification lens, portable video microscope and UV lamp.

Samples were gathered from wooden elements and from painted and gilded plaster. The wooden elements were examined by stereo- and optical microscope under transmitted and reflected light, and UV radiation. A Zeiss Axioskop polarizing microscope was used. The wood taxa identification was carried out according to literature dichotomous keys [15, 16].

The micro-sample from the painted surface, taken from a lacuna in the frame of right panel, was examined by Fourier transform infrared spectroscopy by means of a Nicolet Avatar 360 IR spectrometer.

Polished cross-section of gilded surface layer was also obtained by embedding the micro fragment in a polyester resin (Inplex). The cross-section was examined by Zeiss Axioskop polarizing microscope, equipped with the digital camera Zeiss AxioCam NRc, under reflected light and ultraviolet (UV) radiation produced by a mercury lamp. The acquired images were processed using the AxioVision software. UV observation is particularly useful to better differentiate the painting layers and also to detect organic materials characterized by visible fluorescence induced by UV radiation.

## 3. Results and discussion

Any study aimed at knowledge of a wooden artefact has its starting point in the identification of timber species. There are several methodologies that can be applied in relation to the state of conservation and the possibility to inspect the visible parts of the artefact. In the case of the door of *Santa Maria della Quercia*, a series of observations on the macroscopic characteristics of wood have been performed in order to choose and limit the number of samples to be taken for microscopic observations.

By following this approach, only three wood samples were taken to perform the microscopic investigation in the laboratory. In order to limit the invasive characteristic of sampling, the micro fragments were gathered from areas close to already detached wood parts.

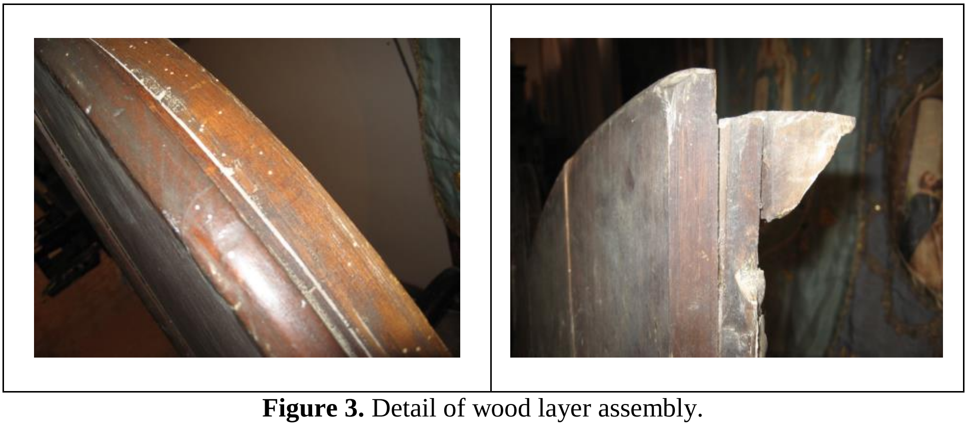

**Figure 3.** Detail of wood layer assembly.

The in situ inspection allowed for revealing that the artefact is made of two arch-shaped panels (Figure 3). The door, 147 cm high, 86 cm wide and 6.2 cm thick, appear composed of a three layers assembly (Figure 3):

- a first wooden element (named A) visible on the back side of the door (Figure 1),

- an intermediate wooden element (named B) that seems to be the support for the front decoration,
- a decorated plaster layer (named C), painted and gilded (Figure 1).

The wooden element A is constituted by boards with vertical grain, the right panel being made of two assembled boards and the left one by three boards. The lack of suitable preservation procedure and maintenance caused the deterioration of the door and especially the presence of dust and cobwebs, probably accentuated by the permanence of the door in the Basilica museum after its removal from the aedicule in 1959. But, the wooden element A seems to be well preserved as regard the biological attack, in fact no larval galleries neither fungal evidences were observed. Some technological defects were revealed on the two panels. In particular, cracks and knots have been documented on both panels.

Concerning wood species, dark coloured and compact hardwood has been observed. The macroscopic observations indicate a ring-porous broadleaf species, as confirmed by the microscopic observation of thin sections. The large early wood vessels were easily distinguishable from the latewood vessels, solitary and arranged in dendritic patterns. The rays were uniseriate (1 cell wide) so they were not visible to naked eye, feature unique among ring-porous species of the temperate regions. The study of the anatomical features of the wood micro-sample allowed identifying chestnut (*Castanea sativa* Mill.).

The wood element B exhibits smaller thickness (about 1 cm) than A. In this case it was possible only the observation of the external edges of the element. It appears constituted by two or more boards with no evident biological attack. Concerning the species, a different kind of wood in respect to that employed in the element A, is probable.

Chestnut is a tree widespread and important both for fruit and wood in Italy. The use of chestnut wood has a long tradition in Italy and particularly in Lazio region. Chestnut wood was used as a structural material for important wooden building frames and artefacts of demo ethno anthropological interest [1, 17]. This observation may suggest the local origin of the chestnut wood. In fact, other studies, carried out on votive tablets of the Basilica of *Madonna della Quercia*, highlighted a constant use of chestnut wood. The manufacture of ex-voto was generally commissioned to local artisans' workshops [1].

The surface decorative layer is composed of four frames, two in each panel of the door. Each frame delimits the figure of an angel with long dress, wings, hands joined on chest, and loose hair. On the frame of each panel, a decoration with alternatively heads of angel and 8-points stars can be observed as symbol of Peretti Montalto family [10, p. 446].

A further thin frame, enriched with floral motifs, surrounds the panels (Figure 1). Lastly, a wooden moulded frame, covered by plaster, encircles the entire door. Wood, from a diffuse porous species, visible only from the inner side of the door, is characterized by diffused larval galleries. Frames are always made of wood. Only the figures of angels seem not to be supported by wood elements, as can be derived by the presence of cracks in the plaster. It may be supposed that the wood matrix in the frames could have been conferred stability to the plaster decoration.

The XRF analysis was performed on seven points, as described in the Table 1. The measuring points can be observed in Figure 4.

**Table 1.** Results of the XRF analysis expressed as cps (counts per seconds of the X-rays of each element).

| Point | Description | Ca | Fe | Cu | Zn | As | Sr | Au | Ag |
|---|---|---|---|---|---|---|---|---|---|
| X1 | Gold angel's dress (top right panel) | 1613 | 460 | 109 | 150 | - | 308 | 376 | - |
| X2 | Gold angel's left arm (top right panel) | 1418 | 1100 | 89 | 165 | 140 | 273 | 162 | - |
| X3 | Gold of the central part of the angel's dress on the fracture (top left panel) | 2031 | 415 | 82 | - | 65 | 375 | 119 | - |
| X4 | Gold small lateral face (top right panel) | 1469 | 618 | 97 | 189 | 105 | 398 | 64 | 113 |
| X5 | Silver background, under the angel (top left panel) | 1279 | 490 | 70 | 138 | - | 316 | - | 114 |
| X6 | Silver background, above the star (top left panel) | 1308 | 402 | 80 | 200 | 82 | 331 | - | 107 |
| X7 | Gold outer frame (top left panel) | 1866 | 345 | 188 | 340 | 109 | 270 | 669 | - |

The reading of the X-ray diagrams, confirmed the presence of gold, in the gilded areas of angels and frames, and silver, in the backgrounds and in the little heads of the frames. XRF spectroscopy detected also high counts of calcium, iron and strontium. Ca and associated Sr are the elements of gypsum plaster under the metal surface; Fe is the main element of ochre used as setting base for metal leaf application.

Sample gilding cross section is shown in Figure 5, both under reflected and UV modalities of irradiation. The stratigraphic sequence, under reflected visible light of the sample (Figure 5 a-c) indicates the presence of two main white preparatory layers that probably are the classical gypsum setting used for preparing the wood panel. Over these two white layers, a thin red-orange layer can be seen in the stratigraphic sequence and it may be associated to bole, used for the application of gold [18]. UV images clearly show a light blue fluorescence in the white setting layers that can be attributed to animal glue, usually mixed with gypsum for obtaining the settings, and a yellow fluorescence in the layer immediately under gold that may be associated to siccative oil (Figure 5 d, e). Lastly, on the surface of the cross section, traces of gilding are visible. As demonstrated by the XRF analysis, gold was not used in its pure state, but associated with other metallic materials such as silver and copper. However, the greater quantity of gold than the other elements (Table 1) demonstrates the use of a very high purity gold leaf.

**Figure 4**. Points of XRF analysis.

A little part of the same sample was used for FTIR analysis by diffuse reflectance (DRIFT) modality. The spectrum is shown in Figure 6.

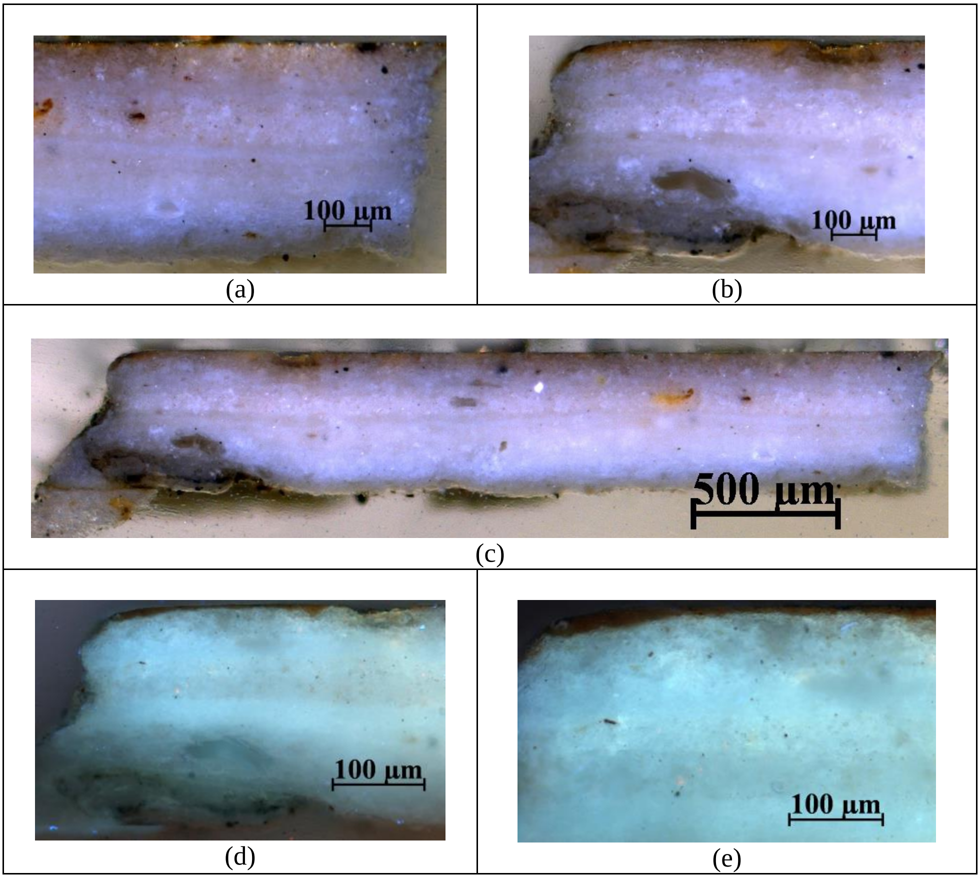


**Figure 5**. Polished cross-section under: (a-c) reflected light and (d, e) UV radiation.

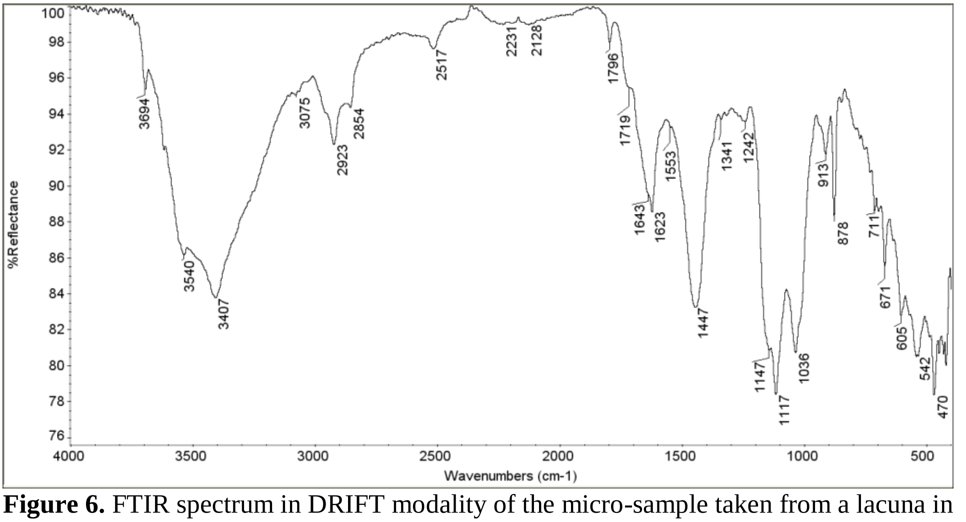


**Figure 6.** FTIR spectrum in DRIFT modality of the micro-sample taken from a lacuna in the upper right side of the door.

The FTIR analysis confirms the presence of gypsum (bands at $cm^{-1}$: 3540, 3407, 2231, 2138, 1623, 1147, 1117, 671, 605, and 470) with minor quantities of calcium carbonate (bands at $cm^{-1}$: 2517, 1796, 1447, 878, and 711). The bands of proteins can also be observed, confirming animal glue in mixture with gypsum (bands at $cm^{-1}$: 3075, 1643, 1553, 1447, 1341, and 1242).

The spectrum reveals another organic compound with bands at $cm^{-1}$: 2923, 2854, and 1719. These bands are probably due to aged siccative oil (linseed oil) but the presence of several compounds make the identification uncertain due to band overlapping. Oil can be used in the mixture used for applying gold.

Finally, the bands at $cm^{-1}$: 3694, 1036, 913, 542, can be associated to the bole components (silicates and iron oxides).

## 4. Conclusions

This paper reported the study on a polymateric artefact that can be recognized as religious and demo ethno antropological heritage. This artefact, the wooden and plaster decorated door of the *aedicula* in the Basilica of *Madonna della Quercia* (Viterbo, Italy), has been investigated both from the historic and material points of view with the aim at gathering information on its conservative history and on its state of preservation. The door represents an important object with a religious aspect for the parishioners of the Basilica of *Madonna della Quercia* and certainly needs to be preserved in order to transmit it to the future generations.

The door was investigated *in situ*, to obtain information on the construction techniques, and in the laboratory through the analysis of micro-samples taken from wood elements and from plaster decoration. The analysis confirmed the presence of gold and silver in the surface decoration applied by bole and gypsum with glue in the plaster setting. Chestnut wood was characterized in the back panel of the door.

The results of analysis are fundamental for the knowledge of the artefact both to support the hypothesis on dating and also as preliminary step in case of a future desirable restoration and of planned maintenance.

## Acknowledgment

The authors thank Dr. Gianfranco Ciprini and the Parrish priest (Don Massimiliano M. Balsi) of Basilica of *Madonna della Quercia* for their help in carrying this work and for their kindness.

## References

[1] G. Agresti, G. Genco, C. Giagnacovo, C. Pelosi, R. Castorina and A. Lo Monaco, Acta Hortic., **866** (2010) 51-58.

[2] A. Lo Monaco, M. Marabelli, C. Pelosi and M. Salvo, Chem. Cent. J., **6** (2012) 47–58.

[3] C. Pelosi, L. Calienno, D. Fodaro, E. Borrelli, A.R. Rubino, L. Sforzini and A. Lo Monaco, J. Cult. Herit., **17** (2016) 114-122.
[4] M. Matteini, *The gilding techniques in the ancient sacred art*, Proc. of the 6th European Symposium on Religious Art, Restoration and Conservation (ESRARC 2014), O.A. Cuzman, R. Manganelli del Fà & P. Siano (eds.), Kermesquaderni, Nardini Editore, Firenze, 2014, V-VIII.
[5] I.C.A. Sandu, M.H. de Sá and M.C. Pereira, Surf. Interface. Anal., **43** (2011) 1134–1151.
[6] I.C.A. Sandu, L. U. Afonso, E. Murta and M.H. de Sa M. H., Int. J. Conserv. Sci., **1(1)** (2010) 47-62.
[7] A. Carvalho, M.F. Vaz, M.M. Ferreira and J. Pires, J. Braz. Chem. Soc., **19(8)** (2008) 1653-1658.
[8] D. Gulotta, S. Goidanich, M. Bertoldi, S. Bortolotto and L. Toniolo, Archaeometry, **54(5)** (2012) 940–954.
[9] K. Keune, J. Mass, F. Meirer, C. Pottasch, A. van Loon, A. Hull, J. Church, E. Pouyet, M. Cotte and A. Mehta, J. Anal. At. Spectrom., **30** (2015) 813-827.
[10] G. Ciprini, *La Madonna della Quercia: una meravigliosa storia di fede*, Vol. I: *La storia, l'arte*, Regione Lazio – Provincia di Viterbo, Viterbo, 2005, 391.
[11] A. Lo Monaco, C. Giagnacovo, C. Falcucci and C. Pelosi, Eur. J. Sci. Theol., 11(2) (2015) 73-84.
[12] G. Genco, C. Maura, A. Lo Monaco, M. Marabelli and C. Pelosi, *A Methodological Approach to the Safeguard of the Wooden Door of Todi Cathedral*, Proc. of the International Meeting YOCOCU, A. Macchia, E. Borrelli & L. Campanella (eds.), De Vittoria, Roma, 2009, 217-221.
[13] A. Lo Monaco, E. Mattei, C. Pelosi and M. Santancini, J. Cult. Herit., **14(6)** (2013) 537-543.
[14] C. Castelli, *L'esperienza del settore Supporti Lignei dell'Opificio delle Pietre Dure di Firenze*, Atti del convegno Minimo intervento conservativo nel restauro dei dipinti (CESMAR7), Il Prato, Padova, 2005, 129-141.
[15] C. Jacquiot, Y. Trenard and D. Dirol, *Atlas d'anatomie des bois des angiospermes: essences feuillues*, CTDB and CNRS, Paris, 1973, 247.
[16] F.H. Schweingruber, *Microscopic Wood Anatomy. Structural variability of stem and twigs in recent and subfossil woods from Central Europe*, Edition F. Flück-Wirth, International Buchhandlung für Botanik und Naturwissenshaften, Teufen AR, 1982, 226.
[17] S. Baldini and A. Lo Monaco, Italus Hortus, **12(5)** (2005) 47-49.
[18] M. Oliveira, E. Murta, L. Dias, J. Mirão and A. Candeias, Conservar Patrimonio, **22** (2015) 41-49.