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# SCIENTIFIC STUDIES FOR THE RESTORATION OF TWO WOODEN ARM RELIQUARIES FROM THE CATHEDRAL OF PALERMO

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## Abstract

Dedicated to Saint Generosi and Saint Rosana, the reliquary arms, recalling the shape of a body part, are today located in the Relics Chapel in Palermo Cathedral. They are probably dated to the second half of the 18th century and are attributed to an unknown artist. The aims of this study were to investigate the decorative techniques, verify the state of conservation of the constitutive materials, measure the microclimate condition in the Relics Chapel, in order to set up a correct preventive conservation strategy. In this regard, an integrated scientific investigation was performed focusing on environmental monitoring (thermo-hygrometric parameters) by HOBO system, characterization of materials constituting the artefacts through optical and scanning electron microscopy (SEM-EDS), and X-ray fluorescence spectroscopy (XRF). The results lead to defining the appropriate restoration project for the two gilded wooden reliquaries.

*Keywords:* gilded wooden reliquaries, wood species, microclimate, SEM-EDS, XRF

## 1. Introduction

The two anthropomorphic reliquaries, probably dated to the second half of the 18th century, belong to a particular category of arm-shaped reliquaries. This

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type of reliquary derived directly from the silver and gold models particularly widespread in the $16^{th}$-$18^{th}$ centuries [1]. During the Counter-Reformation the production of anthropomorphic reliquaries increased to meet the rising demand for these objects due to the renewed cult of the saints and their relics.

The reliquaries of this study are attributable to the two saints, respectively Saint Generosi and Saint Rosana, because of the inscriptions accompanying the bone relics inside the chamber (Figure 1); artworks attributed to the same unknown artist are exhibited in the Relics Chapel, located in an aisle of the Cathedral of Palermo.

**Figure 1.** Reliquaries of Saint Generosi (left) and Saint Rosana (right).

The arm reliquaries (Saint Generosi 71x19x18 cm; Saint Rosana 70x19x17 cm) were realized using three wooden elements (base, pedestal and arm), probably linked by a few metallic nails. They are characterized by the high quality of the wooden carving and the precious decoration in metallic foil; both base and arm are gilded in gold, while the hand is in silver foil. The gilding technique used is the *guazzo technique*, consisting in applying the metallic foil upon a water-based layer called *bolo*. Moreover, the two reliquaries show a fine decoration obtained by chisel technique [2-4], enhanced by a thin glaze of green transparent lacquer. The saints relics, conserved in a silver chamber contain, are referable to two human femurs (R. Miccichè, personal communication).

Before restoration, the reliquaries presented many decay processes related to the constitutive materials, specifically related to the gilding decoration and the preparatory layers. Some previous treatments were also revealed in the Saint Rosana reliquary: the relic chamber was broken and probably re-silvered in the early 20$^{th}$ century.

To perform the restoration correctly, work focused on the characterization of the constitutive materials and the executive techniques; preliminary studies were carried out with multispectral and non-invasive techniques. Micro-fragments, collected from the reliquaries were analysed by optical microscopy, scanning electron microscopy with energy dispersive spectroscopy (SEM-EDS) and X-ray fluorescence spectroscopy (XRF). After restoration, microclimate monitoring of the Relics Chapel and the showcase, where the two reliquaries were displayed, was performed in order to study the potential negative impact of the environment and to prevent decay of the artefacts.

In order to perform the preventive conservation, from January 2016 the microclimatic monitoring (thermo-hygrometric values) was carried out using HOBO data logger placed inside the showcase and the Chapel [5, 6]. Results from three months preliminary monitoring will be shown.

## 2. Experimental

### *2.1. Sampling*

The sampling involved small amounts of original constitutive material taken from the damaged areas. Specifically, the samples SG02, SG03, RB6, RB8, belong to Saint Generosi, while SR01, RB11, RB14, RB4, RB7, RB9 belong to the Saint Rosana reliquary. A description of their colour, typology and location is shown in Table 1.

### *2.2. Diagnostic imaging techniques*

Multispectral and non-invasive investigation techniques such as photography and microphotography in UV and visible radiation (raking light) were chosen as first-step analyses. Specifically, photography in UV and visible radiation were performed, using a digital reflex (DRLR) photo camera (Canon 1200D) equipped with a CCD image sensor (CMOS Canon aps-c, 22.3 x 14.9 mm) and a resolution of 18 megapixels; 18–55 mm f/3.5-5.6 IS STM lens.

### *2.3. Optical microscopy analysis*

In order to identify the wood species, used for the realization of the two reliquaries, micro fragments (SR01, SG03) were sampled from the support of each reliquary, then observed and photographed by optical microscopy.

To identify the component of the preparation layer in sample SGG02, cross-section analysis were performed on samples fragments embedded in a transparent polyester resin. The resin blocks were polished successively with

gradually finer grades of micromesh abrasive cloths until the cross-section surfaces became smooth.

**Table 1.** Table of samples.

| Sample name | Colour and description | Sampling detail | Type of analysis |
|---|---|---|---|
| SG03 | Wood fragment | From the gap of the missing finger | Observation with OM |
| SR01 | Wood fragment | Right angle of the basis | Observation with OM |
| SG02 | Preparatory layers and gilding | Lacuna of vegetal element | Cross-section and observation with OM, SEM-EDS |
| RB4 | Preparatory layer and gilding | Across the fourth pleat of the drapery | XRF |
| RB6 | Preparatory layer and silver | Palm of the hand, near the little finger | XRF |
| RB7 | Preparatory layer and silver | Back of the hand | XRF |
| RB8 | Green pigment | Back of the sleeve, in the cuff | XRF |
| RB9 | Black ink | In the cartouche on the wrist | XRF |
| RB11 | Silver leaf fragment | In the bottom of the relic chamber | XRF |
| RB14 | Plaster | From a lacuna of the frame of the relic chamber | XRF |

### *2.4. SEM-EDS and XRF*

SEM-EDS and XRF measurements were performed on 8 different representative points of the surface of each reliquary. A cross-section of sample SG02 was observed with a Philips Quanta FEI 200 Environmental Scanning Electron Microscope (ESEM) equipped with an energy dispersive X-ray spectrometer (EDS) by Link Analytical Oxford (Link, UK), model 6103. The other samples were analysed *in situ* using the portable X-ray fluorescence spectroscopy (XRF) ASSING Lithos 3000, to characterize the constitutive materials. The results of the micro-invasive and non-invasive analysis are summarised in Table 2.

### *2.5. Microclimate indoor monitoring*

Environmental monitoring was performed by HOBO U-12 006 onset - HOBO Data Loggers, located in the centre of the Chapel and inside the showcase, measuring temperature, relative humidity and illumination.

**Table 2**. Results of micro-invasive analysis.

| **SG03** | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **OM** | Limewood (***Tilia sp.***) | | | | | | | | | | | | | | |
| **SR01** | | | | | | | | | | | | | | | |
| **OM** | Limewood (***Tilia sp.***) | | | | | | | | | | | | | | |
| **SG02** | | | | | | | | | | | | | | | |
| **SEM-EDS** | C | S | Na | O | Ca | K | Mg | Fe | Si | Al | Cu | Pb | Au | Ag | Ti |
| Preparatory layer 'gesso' | 52.11 | 8.61 | 0.39 | 26.76 | 11.38 | --- | --- | --- | 0.46 | 0.29 | --- | --- | --- | --- | --- |
| Preparatory layer 'bolo' | 49.62 | --- | 0.28 | 21.55 | 0.97 | 0.29 | --- | 2.53 | 3.73 | 1.70 | --- | --- | 19.32 | --- | --- |
| Gold | 47.02 | --- | --- | 7.88 | 1.70 | --- | --- | 1.43 | --- | --- | --- | --- | 41.97 | --- | --- |
| **RB4** | | | | | | | | | | | | | | | |
| **XRF** | C | S | Na | O | Ca | K | Mg | Fe | Si | Al | Cu | Pb | Au | Ag | Ti |
| Preparatory layer and gold | --- | --- | --- | --- | 42.80 | --- | --- | 22.65 | --- | --- | --- | 0.13 | 33.35 | --- | 1.06 |
| **RB6** | | | | | | | | | | | | | | | |
| **XRF** | C | S | Na | O | Ca | K | Mg | Fe | Si | Sr | Cu | Pb | Au | Ag | Ti |
| Preparatory layer and silver | --- | --- | --- | --- | 42.72 | 9.06 | --- | 16.12 | --- | 1.06 | 0.10 | 0.10 | 0.09 | 29.36 | 1.34 |
| **RB7** | | | | | | | | | | | | | | | |
| **XRF** | C | S | Na | O | Ca | K | Mg | Fe | Si | Sr | Cu | Pb | Au | Ag | Ti |
| Preparatory layer and silver | --- | --- | --- | --- | 41.28 | 9.04 | --- | 16.22 | --- | 0.56 | 0.15 | 0.05 | 0.07 | 31.53 | 1.06 |
| **RB8** | | | | | | | | | | | | | | | |
| **XRF** | C | S | Na | O | Ca | K | Ni | Fe | SI | Sr | Cu | Pb | Au | Ag | Ti |
| Green pigment | --- | --- | --- | --- | 55.18 | 4.11 | 0.16 | 16.77 | --- | 1.63 | 14.11 | 0.15 | 6.52 | --- | 1.34 |
| **RB9** | | | | | | | | | | | | | | | |
| **XRF** | C | S | Na | O | Ca | K | Mg | Fe | S | Sr | Cu | Pb | Au | Ag | Ti |
| Black ink | --- | --- | --- | --- | 66.15 | 4.37 | --- | 20.25 | --- | 0.64 | 0.63 | 0.09 | 0.08 | 5.79 | 1.97 |
| **RB11** | | | | | | | | | | | | | | | |
| **XRF** | C | S | Na | O | Ca | K | Mg | Fe | S | Sr | Cu | Pb | Au | Ag | Ti |
| Silver | --- | --- | --- | --- | 1.14 | 2.40 | --- | 3.24 | --- | --- | --- | --- | --- | 4.03 | 89.17 |
| **RB14** | | | | | | | | | | | | | | | |
| **XFR** | C | S | Na | O | Ca | K | Mg | Fe | S | Sr | Cu | Zn | Au | Ag | Ti |
| Plaster | --- | --- | --- | --- | 3.51 | --- | --- | 2.60 | --- | --- | --- | 8.35 | --- | --- | 85.52 |

## 3. Results and discussion

Characterization of the constitutive materials, executive techniques, state of conservation and previous restoration treatments were obtained by analysing gilding, preparatory layers, wood and chisel decoration and subsequently combining the results obtained from an integrated analytical approach (optical, SEM-EDS, XRF).

### *3.1. Diagnostic imaging techniques*

The two reliquaries were observed under raking light (visible radiation) before and after the restoration, in order to gain information about the executive techniques and the state of conservation. The decorations of the wood showed how each reliquary, had been worked by the artist using different tools. In particular, closer observation and microphotography revealed geometric patterns and decorative vegetable elements, of small and medium size, made by using different chisels: two with a round head (1-2 mm diameter) and the other with a cross head (2-3 mm diameter).

Finally, there are traces of a bright green transparent pigment, applied by brush in multiple layers, localized within some chiselled motifs. This painting technique, which uses pigments to produce glazes and transparencies, takes advantage of the resulting gloss and the chasing techniques in the gold background to bring out the decorations in the relief (Figure 2).

### *3.2. Optical microscopy analysis*

The optical microscope investigation of SG03 and SR01 samples showed the presence of the lime-wood (*Tilia sp.)* species for both artefacts (Figure 3 and 4).

The deciduous species such as lime-wood and poplar are among the main wood species used for sculpture in Italy, since the thirteenth century. The choice of these species is strictly related to its availability and above all to the individual characteristics of the wood [7-10].

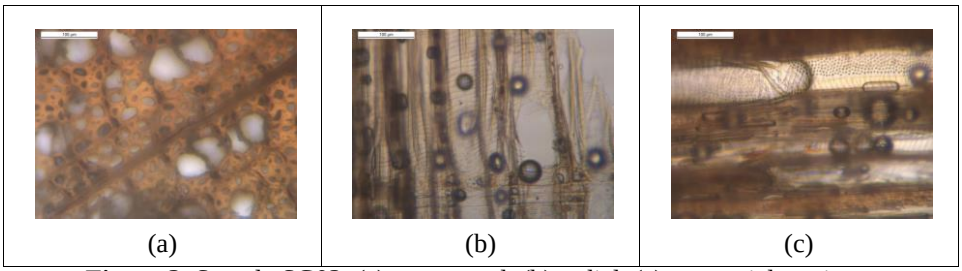
### *3.3. SEM-EDS and XRF*

SEM-EDS and XRF data revealed the composition of the preparatory layer, the quality of metallic foil and the presence of non-original materials.

The cross-section of sample SG02 showed three layers: the preparatory layer, (ground materials and binding medium) is the typical *ammannitura*, composed of two white layers of gypsum and animal glue; coarse grained (first) and finely grained (second) layers [11]. EDS measurements confirmed the presence of gypsum indicated by calcium and sulphur, as well as a second layer due to the presence of clay soils constituting the *bolo*, such as Al, Si, Na, K and Fe. Finally SEM-EDS spectra evidenced the high quality of the metal foil (Au),

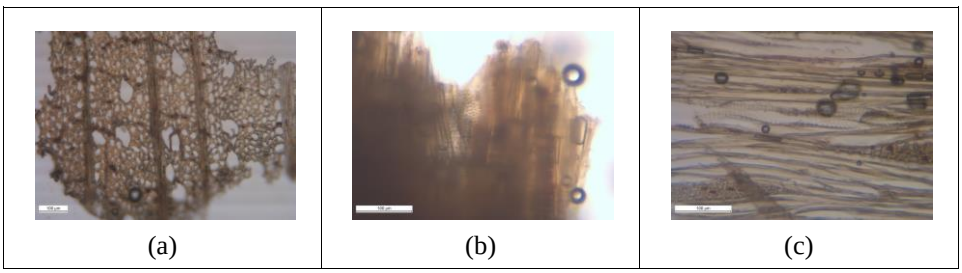
composing the last layer of gilding (Figure 5 and 6). The same results were obtained by XRF analysis of sample RB4.

**Figure 2.** Plant décor items, achieved by chisel technique, enhanced by a thin glaze of green transparent lacquer.



(a) (b) (c)

**Figure 3.** Sample SG03: (a) transversal, (b) radial, (c) tangential sections.



(a) (b) (c)

**Figure 4.** Sample SR0: (a) transversal, (b) radial, (c) tangential sections

As regards samples RB6, RB7, XRF, analysis showed the same composition of the preparatory layer (Ca, S for gypsum and Fe, Si, Na, K, Al for *bolo*) and the presence of high Ag titre in the silver layer. The XRF analysis carried out on sample RB11, collected in the metal foil inside the relic-chamber and on the plaster used to seal the glass (sample RB14), highlighted the presence of titanium (Ti) in the form of metallic alloy and white pigment, in addition to silver; the elements of the other *bolo* and preparatory layers were also detected.

Titanium was probably used in previous treatments during the 20$^{th}$ century. XRF analysis of sample RB8 showed Cu, confirming the presence of copper resinate in the green pigment of the lacquer; the black ink (RB9) is probably iron-gall ink, but the results of the XRF analysis cannot confirm this

hypothesis [http://www.icpal.beniculturali.it/allegati/Ink_ferrogallici_ultima_versione.pdf].

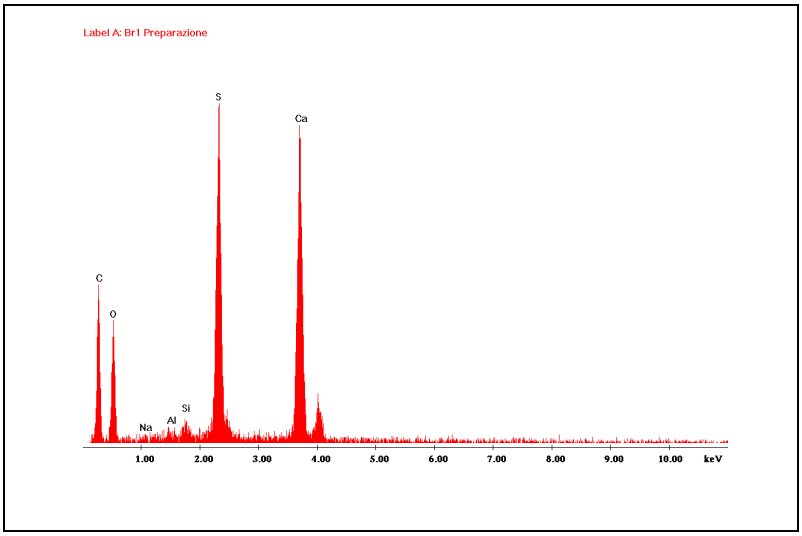



**Figure 5**. SEM-EDS spectrum of sample SG02, referred to preparatory layer.

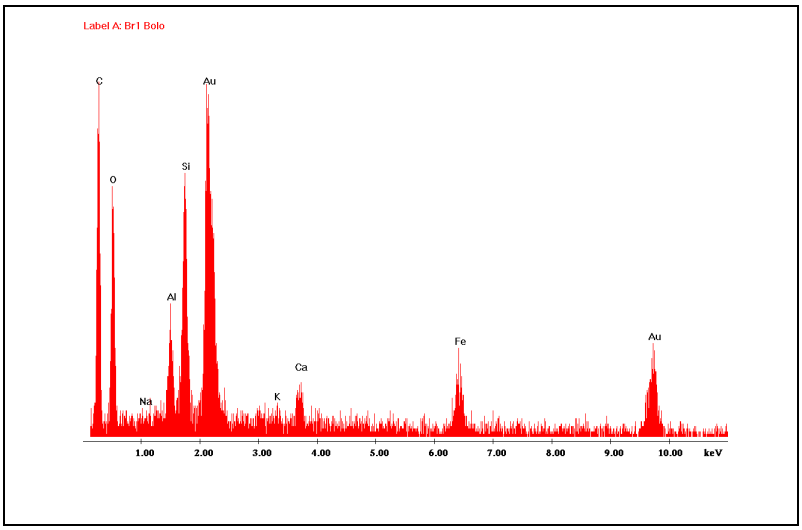



**Figure 6.** SEM-EDS spectrum of sample SG02, referred to the bolo layer.

### *3.4. Microclimate indoor monitoring*

The Relic's Chapel is a confined environment, where the microclimatic parameters are not stable and constants, influenced by many factors such as external-internal climatic seasonal variations, the daily number of visitors crowding the Cathedral. Luckily, the two reliquaries are located inside a niche closed by a glass to protect from theft or vandalism.

The formation of an unsuitable microclimate combined with poor air quality, could induce the degradation, because the wooden sculptures are very sensitive to changes in temperature or relative humidity (RH).

Comparable values of the measured parameters (temperature, humidity and illumination) in the showcase and in the Relics' Chapel (Figure 7) were obtained, showing a close relationship between the microclimate variations in the two environments. The temperature variation in the examined period was about 2°C (17°-19°C in the chapel; 18°-20°C in the showcase), while the daily variation in temperature was about half a degree in the chapel and even less pronounced in the showcase. Relative humidity (RH) showed an irregular trend. It ranged between 44 % and 64% in the chapel and between 48% and 62% in the showcase, with daily variations over 4% ($\Delta RH24h > 4\%$).

Due to the nature of the artworks kept in the chapel, recommended relative humidity values, suitable for preventive conservation, must be in a range from 50% to 60%. We can assume that the showcase provides a more suitable environment than the chapel, where the observed daily variations can be considered harmful for this kind of artefact.

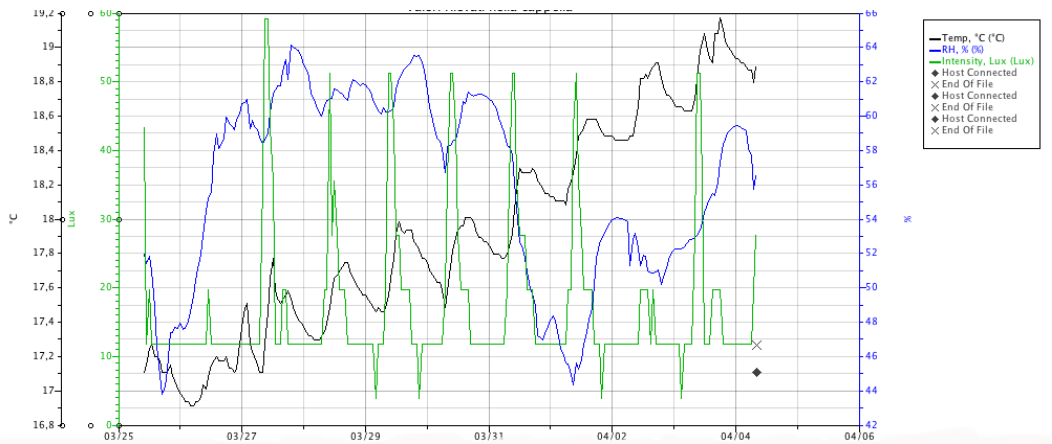



**Figure 7.** The value of the thermo-hygrometric parameters in the chapel.

## 4. Conclusions

The results from physical-chemical and analytical investigations allowed the study of two wooden arm reliquaries, focalized on evaluating their state of conservation and the identification of previous treatments.

Analysis of thin sections allowed the wood species to be identified as lime (*Tilia* sp.). This smooth whitish wood was widely used in Europe and due to its anatomic characteristics, uniform straight fibres and fine texture, was considered an excellent material for sculpture [12].

A fine quality gilding technique was revealed, with highly accurate wooden carving covered by precious metallic foils and embellished by chisel decoration. The study of this category of reliquaries represents a unique

opportunity to improve knowledge and awareness of these particular anthropomorphic objects and the sacred relics they contain. Moreover, study of the microclimate made it possible to correctly develop a plan for preventive conservation of the artworks exhibited in the Relics Chapel.

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