2023 IMEKO TC-4 International Conference on
Metrology for Archaeology and Cultural Heritage
Rome, Italy, October 19-21, 2023

Analysis of materials of wax Christ-children from the Monastery of Santa Rosa in Viterbo

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***Abstract* – This paper reports the results of the analysis performed on three wax Christ-children (wax *Bambinelli*) preserved in the monastery of Santa Rosa in Viterbo. The analysis was performed on the occasion of the restoration, recently concluded, with the aim at supporting the working operations. The characterisation of the materials was particularly relevant for this kind of objects because they are little studied being considered of lesser artistic relevance than other artworks. But the wax babies are very important for their religious values and for technical details and peculiarities: apart from wax, precious textiles and decoration can be found in their dresses and ornaments. The materials were characterised by 2D and 3D ultraviolet fluorescence imaging, X-ray fluorescence spectroscopy, Fourier Transform Infrared spectroscopy, optical microscopy.**
These techniques were used for investigating both the waxy mixture composition and the textile fibers of the babies' hair.

I. INTRODUCTION

This article will describe the diagnostic investigations carried out on three multi-material wax Christ-children (*Bambinelli*) from the Monastery of Santa Rosa, aimed at understanding the constituent materials that compose them to support the recently concluded restoration (Figs. 1-3) [1]. Being the investigated artworks' material (the ceroplastic) heterogeneous and unconventional, the study of its components was necessary in order to be able to plan a conservative restoration intervention capable of respecting the integrity of the materials and ensuring their conservation over time. The *Bambinelli* are composed not only of ceroplastic, but also of glass eyes, fiber hair and, in two cases, by bodies made of padded fabric. The investigated sculptures come from the wax model collection of the Monastery of Santa Rosa in Viterbo which consists of six specimens of Christ-children, a sculpture depicting *Maria Bambina* (Mary as a child), a statuette of Santa Rosa under an arch of paper flowers, and numerous anatomical parts such as the lower limbs, superiors, and heads.

Although it is excluded that the wax models conserved in the monastery of Viterbo were made within the monastic walls themselves, the production of devotional sculptures in wax model developed within the cloistered monasteries for devotional and economic purposes. In this regard, it was of utility the treatise written by the Passionist father Lorenzo Salvi in the first half of the 19th century entitled "Easy and clear way of working wax to make children and other figures" was found, which describes the materials and techniques for making this particular type of artifacts [2].

Fig. 1. Photograph of the Crowned Christ-child (classified as MSR.BAMB.1).

Fig. 2. Photograph of the Supine Christ-child (classified as MRS.BAMB.2).

Fig. 3. Photograph of the Christ-child with coral (classified as MSR.BAMB.3).

Salvi was a proven craftsman of devotional waxworks and wrote this treatise with the aim of donating it to the nuns dedicated to this ancient art who lived in the monasteries that the Blessed visited during his preaching activity. The simulacrums were often kept in the cells of the nuns who paid them daily attention such as prayers and gestures of affection; or they could be sold to contribute to the economic existence of the monastery. The use of wax modelling for the realization of the anatomical parts is due to the search for verisimilitude, as wax has always been appreciated for its qualities of mimesis with the human epidermis following specific processes [3-4].

With the aim at improving the chemical and physical characteristics of beeswax over the centuries various substances have been added such as resins, animal or vegetable fats, flours, pigments, etc. The heterogeneity in the composition of the wax models mentioned in the known case studies has led to the need to investigate the composition of the waxy mixtures of the *Bambinelli di Santa Rosa* in order to be able to carry out the conservative restoration intervention respectful of the original materials.

Diagnostic studies have made it possible to identify the constituent materials of the multi-material works, starting from the composition of the wax mixture, the identification of the fibers that make up the hair and the pigments used to define the chromatic backgrounds.

II. EXPERIMENTAL SECTION

The first step of the investigation was performed on-site by non-invasive techniques: ultraviolet fluorescence imaging (UVF) and X-ray fluorescence spectroscopy.

UVF was performed by a Nikon D800 digital camera, modified in full range. The UV irradiation was obtained using two CR230B-HP 10W UV LED projectors, peak emission at 365 nm working in a complete dark room. 3D UVF model was obtained through a photogrammetric approach as previously detailed [5]. X-ray spectroscopy was performed on site to characterize eventual pigments added to the wax mixture and alloys used for decorating the babies' dresses and for the metal parts of the artefacts. A Surface monitor II by Assing was used, equipped with an Ag anode operating at 40 kV and 76 µA. For each point 60s of acquisition was selected. The registered spectra were processed by Gonio software.

Wax mixture composition was characterised by Fourier transform infrared (FT-IR) spectroscopy through a Thermo Nicolet Avatar 360 instrument operating in the MID-IR from 4000 to 400 cm^{-1} with a resolution of 4 cm^{-1}. Spectra were acquired in diffuse reflectance (DRIFT) modality by accumulating 128 scans for each sample.

FTIR spectroscopy was used also to examine the synthetic textile fibers in order to exactly characterise their polymeric nature.

The textile fibers were examined by polarizing microscope in order to study their morphological

characteristics and to hypothesise their composition. A Zeiss Axioskop microscope was used equipped with transmitted, reflected and UV lighting. Images were acquired by a digital AxioCAM camera connected to the microscope and to a computer and processed through the software AxioVision.

III. RESULTS AND DISCUSSION

UVF imaging allowed to investigate in detail the surfaces of the wax Christ-children by revealing superimposed materials, dust, retouch, etc. This technique has great relevance in the restoration as preliminary step to map the conservation status, the possible previous interventions on the artworks, the presence of fluorescent materials (pigments and binders) etc. [6-10]. The knowledge of the surface materials and condition is of great importance for planning the most appropriate cleaning and treatment of the artworks' surface [11].

The UVF images of the three wax children are shown in the Figs. 4-6; the 3D model of the crowned Christ-child is available at the link: https://sketchfab.com/3d-models/modello-3d-bambinello-corona-8d6a084e53144fb98174b8a0671ca4d5, on the Sketchfab platform.

The main evidence from the observation of the UVF images is the presence of surface dirt and deposits, particularly highlighted on the crowned Christ-child where residues of glue and other materials are clearly visible on the forehead and under the hair (Fig. 5).

Fig. 4. UVF images of Christ-child with coral, front and back sides.

The wax mixture exhibits a light blue fluorescence, visible on the Christ-child with coral and partially on the crowned Christ-child that can be associated to the wax. In the case of supine child, the surface fluorescence is of pale-yellow colour probably due to the presence of a surface material covering the wax (whose fluorescence is partially visible in correspondence of the surface abrasions). By observing some details of the UVF images, it has been detected the presence of a yellow fluorescence particularly evident in the cheek, in the thigh and in the knee of the baby with the coral bracelet (Fig. 7). This kind of fluorescence can be attributed to the zinc white (zinc oxide) that generally shows a lemon-yellow response under UV radiation [5].

Fig. 5. UVF images of the crowned Christ-child, front and back sides.

Fig. 6. UVF images of the supine Christ-child, front and back sides.

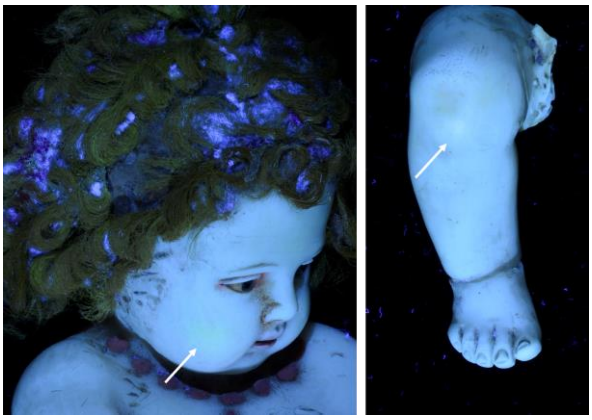

Fig. 7. Details of the UVF images of the Christ-child with coral, face and knee. The arrows indicate the zone with yellow fluorescence due to zinc white.

On-site analysis was completed by XRF spectroscopy that was performed with the aim at detecting chemical elements with atomic number higher than 16 (S, sulfur, that is the limit of the used p-XRF instrument).

Table 1. Result of XRF analysis expressed in term of detected elements. Hypotheses about composition of the examined areas are reported in the table.

Point of XRF measure	Detected elements	Hypothesis on composition
X1 –Child with coral, belly	Pb	Lead white
X2 –Child with coral, thigh	Pb, Zn	Lead white and zinc white
X3 – Child with coral, shin	Pb	Lead white
X4 – Child with coral, knee	Pb, Zn, Hg, Cd, Ca	Lead white, zinc white, vermilion
X5 – Child with coral, fronthead	Pb, Zn	Lead white and zinc white
X6 – Child with coral, eyebrows	Pb, Zn, Fe, Mn, Ca	Lead white, zinc white, iron-based earths
X7 – Child with coral, bracelet	Pb, Hg	Lead white and vermilion
X8 – Child with coral, lips	Pb, Hg	Lad white and vermilion
X9 – Child with coral, metal yarn	Cu, traces of Cd, Ag and Pb	Copper alloy
X1 – Supine child, fronthead	Pb	Lead white
X2 – Supine child, mouth	Pb	Lead white
X3 – Supine child, left eye pupil	Pb, Mn, Sb, Ca	Glass colored with Mn compounds
X4 – Supine child, back	Pb	Lead white
X5 – Supine child, metal yarn	Cu, traces of Fe	Copper alloy
X6 – Supine child, hair	Ca, traces of Fe	Organics
X7 – Supine child, lips	Pb, traces of Fe	Lead-based red
X1 – Crowned child, metal crown	Ag, Cu	Silver alloy
X2 – Crowned child, cheek	Pb, Hg	Lead white and vermilion
X3 – Crowned child, lips	Pb, Hg, Fe, Ca	Lead white, vermilion, iron-based earth
X4 – Crowned child, eyebrows	Pb, Fe, Mn, Ca, Hg	Lead white, iron-based earth, vermilion
X5 – Crowned child, nipple	Pb, Hg, Ca, Fe	Lead white, vermilion
X6 – Crowned child, metal yarn	Cu, Au, traces of Fe	Copper alloy with gilding
X7 – Crowned child, golden fabric	Cu, Fe	Copper with traces of iron
X8 – Crowned chidl, eye	-	Organics

The presence of lead in the points corresponding to the wax mixture suggest the use of lead white in the mixture.

This pigment was generally added to the wax mixture in order to whiten the material, being natural beeswax of a yellow-brown colour, and to make it more similar to the flesh tone. This result is also in accordance with the ancient treatises that reported recipes for preparing wax mixtures for sculptures, in particular with that of Beato Lorenzo Salvi [2]. The Salvi's treatise, written in the first half of the 19th century, contains all the useful information for the creation of ceroplastic figures. It was addressed to the nuns dedicated to this art and residing in the monasteries where Salvi visited, as in the case of the nuns of the Passionist Monastery of Tarquinia a town very close to Viterbo, where the Monastery of Santa Rosa is located.

To characterise the composition of the wax mixture, samples from the three sculptures were taken for laboratory analysis through FT-IR spectroscopy. Similar spectra were obtained from each sculpture, thus only the spectrum of the sample taken from the supine baby is reported (Fig. 8).

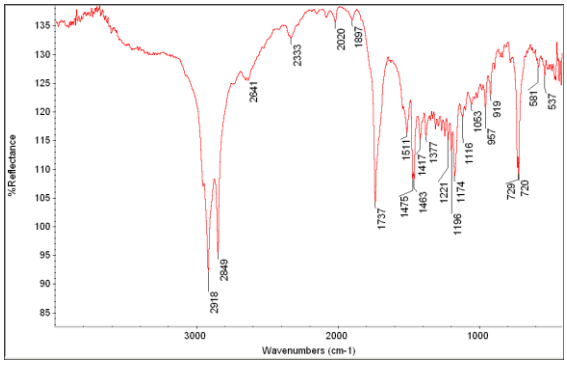

Fig. 8. FT-IR spectrum of a sample from the supine Christ-child.

The main signatures in the spectrum of Fig. 8 can be associated to wax that is characterised by very strong and

sharp bands at 2918-2849 cm^{-1}, 1476-1463 cm^{-1} and 729-720 cm^{-1}, typical of C-H bonds of long-chain hydrocarbons [12]. The strong carbonyl band at 1737 cm^{-1} suggest the presence, in the mixture, of lipidic substances such as oils or fats that usually were added to the wax, as indicated also in the ancient treatises [13-17]. Other signals can be referred to paraffin (2333, 1377, 2020, 1897, 1511 cm^{-1}) that was generally added to the mixture of wax for creating sculptures. To investigate further compounds suggested in the treatises but not revealed in the FTIR bulk analysis, a sample was extracted with acetone in order to solubilize the possible terpene resin that, according to the ancient recipes for wax modelling, was added to the mixture.

The obtained spectrum is shown in the Fig. 9. The spectrum shows the main signals of a lipid substance. The greatest similarities in the database (Nicolet standard Collection of FT-IR spectra, Index Nr. 1354, CAS Nr. 1338-41-6) available in our laboratory are with stearates (about 90%) which are salts of long-chain acids with a waxy appearance. They have various uses such as emulsifiers, viscosifiers, emollients, etc. Furthermore, with the extraction process some signs have emerged that lead back to a natural terpene-based resin.

In particular, the signals at cm^{-1}: 1710, 1463, 1377, 889. The greatest resemblance would appear to a dammar resin or mastic [18].

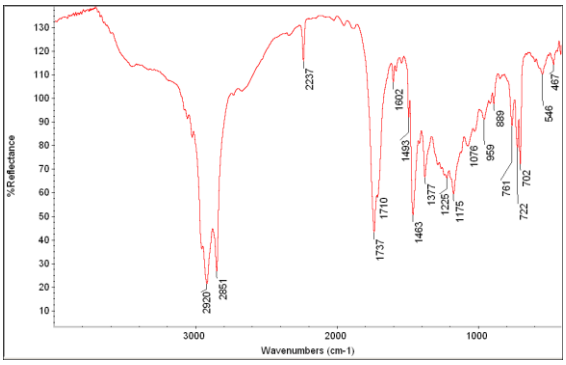

Fig. 9. FT-IR spectrum of the same sample of Fig. 8 from the supine Christ-child but extracted in acetone.

The analysis of the fibers of the hair was conducted by optical microscope observation and FT-IR spectroscopy.

The fibers of the hair of the MSR.BAMB.1, crowned Christ-child, are very thin and regular without interruptions and particular weaves (Fig. 10A-B). It is certainly a synthetic type of fiber, with characteristics that suggest a modified cellulosic one, such as rayon [19-20].

Even the hair fibers of the MSR.BAMB.3, supine Christ-child, are very thin and regular without interruptions and particular weaves. Surely it is a synthetic type of fiber, with characteristics that suggest a polyester or polyamide type fiber (Fig. 10C-D).

To confirm the fibers composition, they were examined by FT-IR spectroscopy that gave the typical spectra of a polysaccharide compound (for rayon) and amidic polymer (for nylon).

The result was very interesting because supply information about the time location of the hair. Rayon, in fact, is a more ancient textile fiber in respect to nylon. In fact, it was developed in France in the 1890s and was originally called "artificial silk".

In 1924, the term rayon was officially adopted by the textile industry [20]. On the other hand nylon fibers date back, as synthesis and subsequent marketing, to the end of the 1930s even if a first reference to their use in works of art can be found in 1958 [21-22].

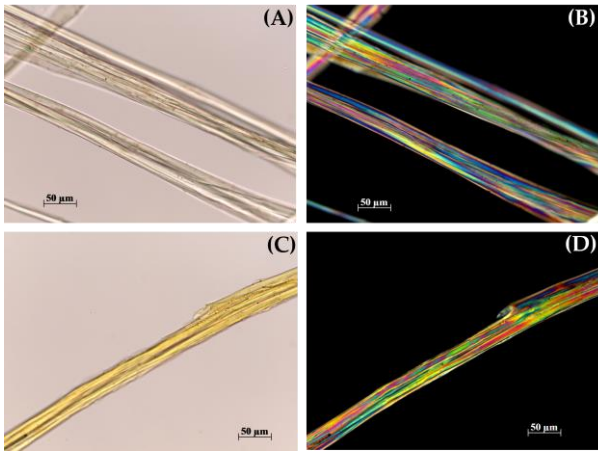

Fig. 10. Microphotographs of fibers at magnification 200X. (A) and (B) crowned Christ-child under parallel NP and crosses NX polars respectively; (C) and (D) supine Christ-child under NP and NX.

IV. CONCLUSIONS

The diagnostic and analytical campaign for the investigation of three wax Christ-children was fundamental to gather information on the constituent materials especially due to the lack of literature works on this specific topic. The obtained knowledge on the wax mixture composition and on the fibers of the hair was also relevant both to address the restoration choices (that will be object of a future specific paper) and, above all, to prepare sample mocks-up for laboratory testing of consolidant and adhesive before applying them on the artworks.

Wax mixture was composed of beeswax, paraffin, a fatty substance, a terpene resin and lead white, this last used to whiten the surface and make the colour like the flesh tone. This mixture has been found a match with the treatise of Lorenzo Salvi written in the first half of the 19th century and giving all the useful information for the creation of ceroplastic figures to be used in monastic contests.

In conclusion, we think that this paper can constitute a new important piece that will fill the lack of knowledge of ceroplastic artifacts, considered of lesser artistic value, but certainly of great religious and anthropological value.

ACKNOWLEDGEMENTS

The restoration was carried out as part of the activities of the master's degree course in Conservation and Restoration of the University of Tuscia with the contribution of the Centro Studi Santa Rosa da Viterbo.

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