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An experimental approach to the cleaning of a polymateric textile weave: set-up of the alternative methodology and instrumentation

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***Abstract* – Aim of the present research is the setup of an alternative methodology and instrumentation to be applied for cleaning ancient tapestries which need restoration.**

A new instrument based on the simultaneous dispensing and aspiration of water (hydro-aspiration method) and capable of removing the deposited particulate matter (DPM), has been developed and its performances tested on an ancient polymateric tapestry belonging a precious series called "*Ulysses Stories*", stored at the Quirinale Palace (Rome).

This innovative system has been compared to traditional methodologies commonly employed by restores for tapestries cleaning operations.

At this purpose, the quantity and the chemical composition of the particulate matter removed by the different systems and collected on quartz fibre filters, have been estimated. Different analytical techniques have been applied to this purpose.

The hydro-aspiration method resulted to be more efficient in removing the dirt and also in preserving the structure of these precious metallic yarns.

I. INTRODUCTION

This study stems from the need to identify the correct cleaning method to be applied to a polymateric tapestry (Fig. 1) belonging to the "*Ulysses Stories*" series stored at the Quirinale Palace (Rome) and in particular to the gilded silver and gold metallic yarns, whose conservation state required the preservation of the "self-protection" patina and gilding traces, because of the future exhibition inside the Palace [1]. Although the Quirinale Palace has modern warehouses and laboratories that allow the conservation, restoration and rotation of the tapestries, their exhibition takes place inside a 'living' monument, where the tapestries are also employed for their original use and furnishing needs.

This tapestry has been recently studied by a multi-analytical approach to acquire information on the chemical nature of the organic colourants employed for dying it [1-3].

This textile weave is a border fragment of a polymateric tapestry where wool, silk and metallic yarns have been employed. In the centre, there is a woven in metallic yarns representing a medallion (Fig. 1) with the clients' monograms surmounted by a crown. On the sides, in polychrome wool and silk yarns, there are two flowers festoons and garlands.

Aim of the present research was the setup of an alternative method to the state of the art, to be applied to the tapestry to remove the dirt residues preserving at the same time the fragile metallic yarns which presented as covered by an oxidative patina.

Fig. 1. Lower border fragment of the "Ulysses Stories", Bruxelles, 1665-66, 72x172 cm. Rome, Quirinal Palace.

At this purpose, a new instrument, based on a hydro aspiration mechanism, has been realized.
This innovative system has been compared to traditional ones and turned out to be more effective in removing deposited particulate matter (DMP) at the same time preserving the metallic yarns.
Furthermore, the quantity and the chemical composition of DPM removed by the different systems from the tapestry surface and collected on quartz fibre filters, have been estimated. Different analytical techniques including IC (Ion Chromatography) SEM-EDS (Scanning Electron Microscopy coupled with Energy Dispersive Spectroscopy) and TOT (Thermal-Optical Transmittance) have been applied to this end.

II. MATERIALS AND METHODS

A. The hydro- aspiration cleaning system and the traditional cleaning methods

The prototype instrument (Fig. 2) is based on the liquid dispensing and simultaneous aspiration of the removed dirt (Fig. 3). The set-up device can fulfil several restoration phases allowing the removal of the deposited particulate matter and the textiles cleaning.

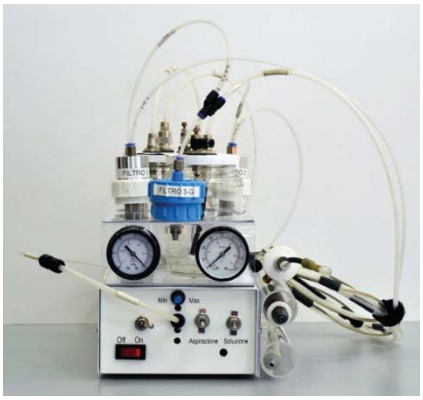

Fig. 2. The hydro-aspiration system

The device consists of three parts that allow the controlled delivery of the aqueous solution, the micro-macro aspiration and the mechanical action of tools and tips.
The hydro-aspiration system, which allows a simultaneous physical-chemical action, has been applied on the metal yarns localizing in this way the cleaning and controlling the intervention.

Fig. 3. How the hydro-aspiration system works on the yarns.

The traditional methods commonly used for cleaning tapestries, that have been compared with the hydro-aspiration system, are air aspiration, low-pressure table and immersion washing [1, 2].
The new hydro-aspiration system and the traditional methods have been applied to selected areas of the tapestry having a dimension of 3x3 cm. The cleaning tests were performed by preparing an aqueous solution (deionized water) containing a non-ionic surfactant (Saponina, Carlo Erba) at 0.02%. During the tests, the deposited particulate matter (DMP) was collected on quartz fibre filters (QM-A, Whatman). Each cleaning method has foreseen three tests, carried out under stable conditions (pH≃ 6, T≃ 18 °C).

B. The analysed tapestry

The cleaning procedures have been applied to the lower border fragment of the "*Ulysses Stories*" series, Quirinale Palace (Rome) [1] (Fig. 1). The border fragment is a part of the tapestry "Ulysses bids farewell to Alcinoo" and was made, together with the other pieces belonging to the series of Brussels, at the workshops of Jan van Leefdael (Brussels, from 1644 to 1680) or Geraert van der Strecken (Brussels, from 1647 to 1677), on cartoons by Jacob Jordaens (1635).
This border fragment is a polymateric tapestry with wool warps and wool, silk and metallic wefts, forming the work structure and the design. It is characterized by the presence of a crown and two flower festoons, on a brown background, which encloses a blue circular plate on which is inscribed, in golden letters, the monogram with the

initials of Charles Emmanuel II of Savoy and his wife, Maria Giovanna Battista of Savoy-Nemours. The crown motif and monogram are embellished with gilded silver and gold metallic yarns used with the *crapautage* technique.

C. *The analytical methods*

The quartz fibre filters employed in the hydro-aspiration and traditional systems, have been weighed before and after the cleaning procedure to quantify the deposited particulate matter (DMP).

Main ions quantification has been performed by IC (Ion Chromatography) analysis using an ICS-1000 HPLC system equipped with a conductivity detector [4].

The determination of OC (organic carbon) and EC (elemental carbon) has been carried out using a TOT (Thermal-Optical Transmittance) Sunset instrument following the methodology conventionally used for their determination in the aerosol particulate matter [4, 5].

Both selected areas and single particles present on the filters were analysed by SEM-EDS (Scanning Electron Microscopy coupled with Energy Dispersive Spectroscopy) to obtain qualitative/semiquantitative information on the chemical composition. The instrument employed was a Hitachi TM1000 equipped with an energy dispersive X-ray spectrometer (Oxford Instruments SwiftED). Measurements were directly performed on samples since no metal coating was required [6].

Furthermore, a SEM-EDS TESCAN MIRA 3 instrument has been employed to study the metallic yarns morphology and the chemical composition of the surface patinas.

III. RESULTS AND DISCUSSION

The conservation of textile artefacts is a quite complex issue. Dust deposition is a preservation concern in the case of ancient textiles whose cleaning is quite challenging.

The impact of DPM on textiles, together with the absorption of gaseous pollutants such as SO_2 which can cause oxidation phenomenon, is a well-known phenomenon. For example, it has been investigated in some French museums characterized by different environmental conditions (urban, semi-rural and marine environment) [7].

As stated before, the tapestry examined in the present paper is a polymateric textile weave. The crown and royal monograms presented an evident deterioration of the metal threads of both physical or chemical nature, i.e. abrasion of the thin gold layer and presence of corrosion products.

The metallic yarns' degradation has caused the alteration of the original chromatic effect. What was once supposed to appear golden yellow, is now greyed and opaque.

The formation of silver corrosion products is caused by oxygen, moisture and atmospheric constituents such as SO_2.

Generally, corrosion products are silver sulphide (Ag_2S), silver oxide (Ag_2O) and silver chloride (AgCl) in traces [8].

In Fig. 4 an image of a yarn with traces of the original gilding (red arrow) on the silver foil (blue arrow) is reported while in Fig. 5 an EDS analysis of the corrosion products, mainly formed by Ag_2S, is shown.

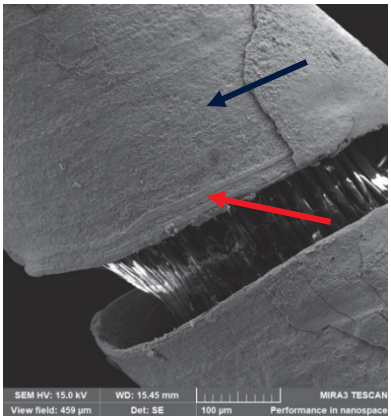

Fig. 4. SEM-EDS image of a yarn: traces of original gilding (red arrow) on the silver foil (blue arrow).

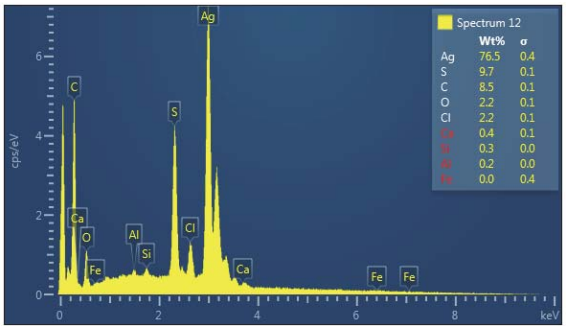

Fig. 5. SEM-EDS analysis of the yarn highlighting the presence of corrosion products on the metal yarn.

The metallic yarns peculiarities, as evidenced by SEM-EDS analyses (Fig. 4 and 5), have highlighted the need to study a cleaning system suitable for dirt removal.

As a consequence, because of the fragility of the textile and the need to clean it, but at the same time preserving the integrity of the metallic yarns, a new innovative instrument has been realized (Fig. 2).

The cleaning method developed in this study, i.e. the so-called "hydro-aspiration" system, represents an alternative to conventional systems generally applied by the restorers.

The innovative set-up method has been therefore compared to the traditional systems, i.e. air aspiration (physical action), low-pressure table and washing by immersion in aqueous solution (physical-chemical action) [2]. Some examples of quartz fibre filters with DMP collected on them, are reported in Fig. 6.

To assess the performances of the hydro-aspiration method with respect to the traditional ones, the quantitative and compositional analysis of DMP has been performed.

Fig. 6. Quartz fibre filters where DMP has been collected by the different cleaning procedures.

Regarding the capacity of removing dirt particles, the new alternative method here proposed turned out to be the most performant. This has been evidenced first of all weighting the quartz fibre filters before and after the cleaning operations, confirming how the hydro-aspiration system was able to remove the higher DPM quantity.

Furthermore, the filters collected with the different procedures have been examined by SEM-EDS allowing to evidence, in some cases, that the specific type of cleaning system used could be harmful to the metallic yarns by removing small particles of gold, such as the one shown in the Fig. 7 which reports the image of a quartz fibre filter collected with the aspiration system. As a consequence, this methodology turns out to be too invasive for the tapestry.

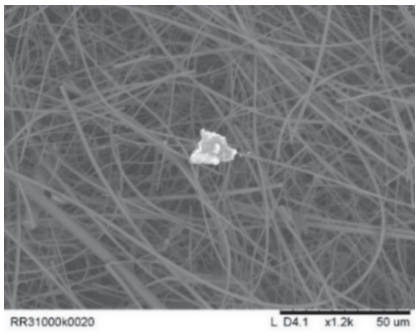

Fig. 7. SEM image acquired on a quartz filter highlighting the presence of a gold particle.

Furthermore, comparing the capacity in removing specific particles, it has been demonstrated that the hydro-aspiration method allowed to remove the higher quantity of ions (in particular chlorides, sulphates and nitrates).

As regards the removal of carbonaceous species, i.e. organic carbon (OC) and elemental carbon (EC), the new method was the most effective. In Fig. 8 the quantities of OC, EC and TC (which is the sum of two) present on the quartz fibre filters are reported evidencing how the highest concentrations are removed within the first minutes of the cleaning procedure (in this case after each time interval the filter mounted on the apparatus was replaced with a new filter). On the contrary, OC and EC determined on filters collected with the conventional cleaning systems were significantly lower.

It is worth noting that elemental carbon, also known as black carbon, due to its characteristic dark colour, is the main responsible for the blackening of the surface. The quantity removed (Fig. 8) is quite lower with respect to OC and only a few hypotheses can be advanced to explain this; perhaps elemental carbon could be more adherent to the surface of the tapestry and consequently more difficult to be removed.

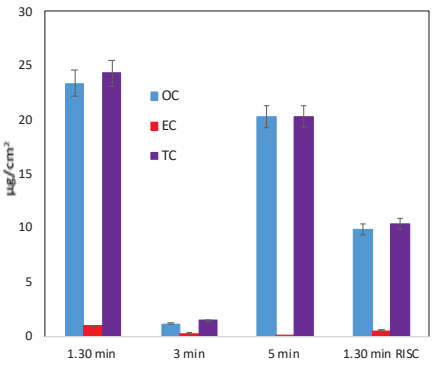

Fig. 8. Results of TOT analyses showing the concentrations of OC, EC and TC determined on quartz fibre filters mounted on the hydro-aspiration system and collected at certain time intervals.

IV. CONCLUSIONS

The innovative aspect of this study consists in proposing a new approach to cleaning procedures suitable for those works of art that, presenting particular characteristic such as a polymateric composition, require a direct and localized treatment, based on the combination of two or more systems.

Because of the fragility of the textile and the need to clean it, but at the same time preserving the integrity of the metallic yarns, a new innovative system has been realized. In this way a new conservative approach to the intervention has been proposed.

It has been demonstrated how the new system here proposed is the most effective in removing DPM from the tapestry.

At the same time, the hydro-aspiration system turned out to be the less invasive method towards the metal yarns allowing to preserve them avoiding the remotion of the fragile corrosion patinas.

In the future, this kind of approach could be also extended to three-dimensional textile objects.

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