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Corrosion off Metal Threads in-Situ: Case Study

Wafaa Mohamed [1], Mai Rifai, [2] and Fatmaa El Zahraa Sadat[3*]

1 Conservation Department, Faculty of Archaeology, Cairo University, Egypt.
[2] Conservation Department, Faculty of Archaeology, Cairo University, Egypt.
[3] Conservation Department, Faculty of Archaeology, Cairo University, Egypt.

Abstract

Vintage textile items with decorated metal threads represent a special sort of overwhelming treasure of cultural collections that is why a distinctive concern is highly needed to keep them well-protected in museums and private collections. Cleaning corroded metal threads was dealt with by either mechanical or chemical means; with limited success.

Clinical Ultrasound scaler represented an appropriate solution that aid scaling of minute corrosion layers on gilded metal threads with a great controllability in-situ (museum). A stored vintage decorated fabric dated to 17-18th century A.D, was selected for being cleaned. Cleaning with Piezoelectric ultrasound waves with localised vibrational mechanical actions was successfully carried out at a power range to be approximately 7.25-9.37 watts. Portable microscope aided monitoring the scaling process at the worktable stage, with no harm to the accompanying materials.The rapidity and accessibility of cleaning not to be comparable by other method, with the controllability all at once.

Keywords

Metal threads, corrosion, ultrasound waves, ultrasound probe, corrosion, scaling

1. Introduction

The problematic issue of each time that most of the museum conservators face is cleaning corroded/blackened metal threaded-fabrics in museums and collections. The debate about whether to clean, or not is the main concern of many researchers. If to clean, what the ideal method to be followed keeping the integrity of all involved materials (Simpson and Huntley 1992). Due to these difficulties, Some preferred not to clean the metal threads at all (Howell 1989). Mechanical means probably occasionally described to be safer; even though they will take some time with limited effect; compared to chemical means that showed to be rapid; but very risky and have detrimental effects for the metal(Landi, 1998),(Indictor et al.1989).

Based upon an experimental study previously carried out on fragments from the same metal threads to prove the efficacy of this clinical tool to efficiently clean corroded metal threads (Sadat, F.E., 2011).The obtained results were applied upon the case study here in the museum where it was located. Ultrasonic scaler/probe; or UDS" as abbreviated through the study, provided a valuable tool to clean corroded metal threads in-situ.

Ultrasonics is the science of sound waves above the limits of human audibility. Frequencies above 18 KHz are usually considered to be Ultrasonic. The most commonly used frequencies for cleaning are those between 20 and 50 KHz (Hancock, J., 1999, 5). The piezoelectric transducer "PZT" is the most widely transducer used in cleaning applications. The ultrasound sources or the ultrasound transducer, which changes the energy received from the source into acoustic energy (Kanegsberg, B., 2001, 219).

2. Materials and Methods

2.1. Case Study Description

The case study is a gilded copper-based threaded; suggested to be a table cover; which was stored at the museum of Faculty of Applied Arts in Helwan University, Egypt(fig.1).The fabric is rectangular in shape. Its dimensions are as follows: the upper width is 142 cm;whereas the lower -the cut edge- is 150 cm. The two other sides are about 88 cm.the difference in dimensions of two long opposite sides probably attributed to the existing degradation of the ground fabric than the areas

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decorated; due to the preservative effect of the metal itself when present with the textile.

fig.1. A General View of the Case Study

2.2. Examination &Analysis

Cross section study was carried out on mounted specimens of tiny fragments representing metal threads. They were examined as polished, and etched. Environmental Scanning Electron Microscopy was involved, equipped with Energy Dispersive X ray Spectrometry (ESEM+EDS) was involved to analyse the composition of the metal alloy (fig.5)

X-Ray Diffraction was involved to confirm EDS results to get an idea about black corrosion compounds(fig.6). Polarizing Microscope (PM) of metal threads to reveal surface morphology and black corrosion (fig.2).Scanning electron micrographs aided identify the lengthwise and crosswise yarns of the ground fabric; upon which the metal decoration was applied (fig.3).

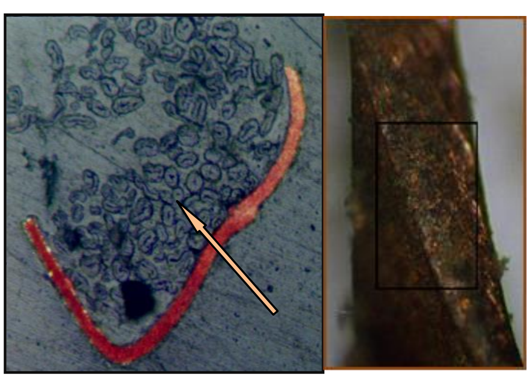

Fig.2. A polarizing image of the etched mounted specimen showing the kidney-shape or lima bean grains centered, surrounded by the brassy reddish metal strip with the remaining gilding (left:Mag.20x).Polarized Image of the black spots, and greenish flakes along the edge of the separated metal strip (Mag. 40x).

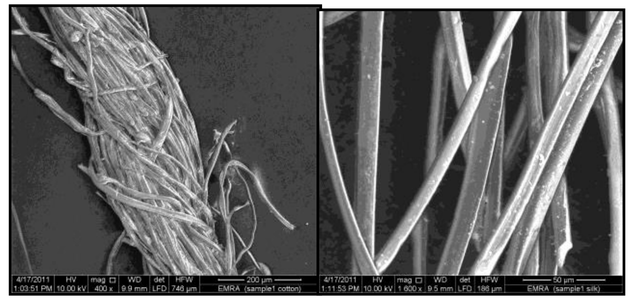

Fig.4.ESEM of the lengthwise warp from the ground fabric as The convolutions were clearly seen(left); ESEM of crosswise weft yarns from the ground fabric as smooth tubes were clearly seen(right)

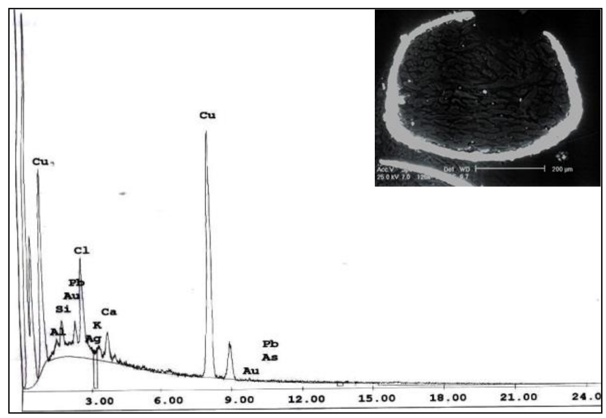

Fig.5.micrograph of the mounted specimen; and the corresponding analysis spectrum "area scan"(200µm)

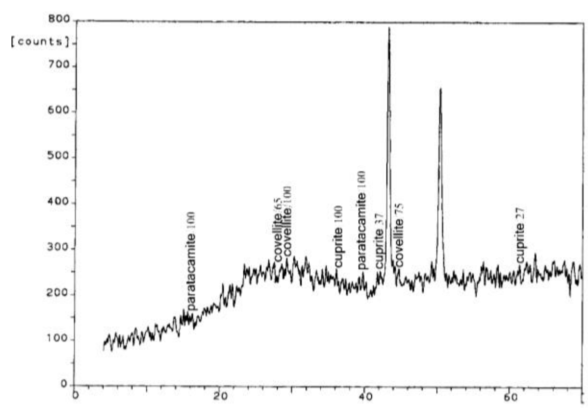

Fig.6.XRD identification of the black Corrosion on the decorative metal.

2.3. UDS Set-up

Unit of Ultrasonic Dental probe/ scaler consisst basically of a generator "electrocircuit", a transducer (detachable hand piece). The generator provides electrical energy which is converted by the transducer to mechanical energy in the form of vibrations. the model specification being used was Ultrasonic Dental Piezo Scaler, Model: UDS-J.(fig.7) Piezoelectric transducers, were preferred than magnetostrictive scalers, as the former converts the alternating electrical energy directly to mechanical energy through use of the piezoelectric effect in which certain materials change dimension when an electrical charge is applied to them. Water supply, attached with the unit, was not needed. Any water or wet application was certainly avoided; in order to prevent any more corrosion on metal on the short- or long-term.

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fig.7. The involved ultrasound unit for application (After Spring, S., 1974, 32).

Based upon an experimental study has previously done, mid-range power range was selected to be involved. Therefore, the scaler was adjusted at the mid-power range (3-4) during scaling process; according to the knob indicators, which mathematically calculated, according to device specifications(output power), to be approximately 7.25-9.37 watts. This is considered the ideal power meter to be used for scaling corrosion layers.in addition to the selection of the suitable scaling tip, which considered the second important factor, which matches the metal strip wrappings and curving. this selection depends a lot on skillfulness and the practice of the conservator.

Ethyl alcohol was used for immersing the scaling tip from time to time for cooling purpose; trying to avoid the limited localised thermal effects probably occur on the cleaned areas; instead of water supply unit being attached to the unit and specified for cooling purpose and relaxing the vibrations in oral cavity during clinical operations.

The case study was temporarily put on white light-weighted foam support to facilitate to be moved during the different stages of restoration(fig.8). A small blower such as that used by watchmakers used to reach the interstices of the embroidery which can be difficult to reach by other means. Blowing across the surface towards one side, keeping the rest of the object covered, otherwise the dust is merely redistributed. In addition, the debris generated during cleaning will be removed. Small fibre glasses aided the scaling process by the ultrasound(fig.9).cleaning from the back side of the case study was started with; as the decorative knots that fixed the decorative pattern from the face.starting from the back aided the face to be effortlessly cleaned with sufficient efficiency.A piece of paper with a small hole was sued to help the decorative knots to be easily cleaned, separated from the rest of the fabric.

Fig.8 The worktable within the temporary support, The studied object above,

Fig.9.cleaning the back side using small fibre glass aided by wooden toothpicks, and the scaling tip selected for the cleaning.

Turning over the object on the temporary support, the front side was cleaned within the standard parameters with mid-range (3-4).Rationally it can be guessed how the cleaning process is trouble-free and time-saving. Portable Digital Microscope was involved for inspecting what occurred under the scaling tip of UDS.

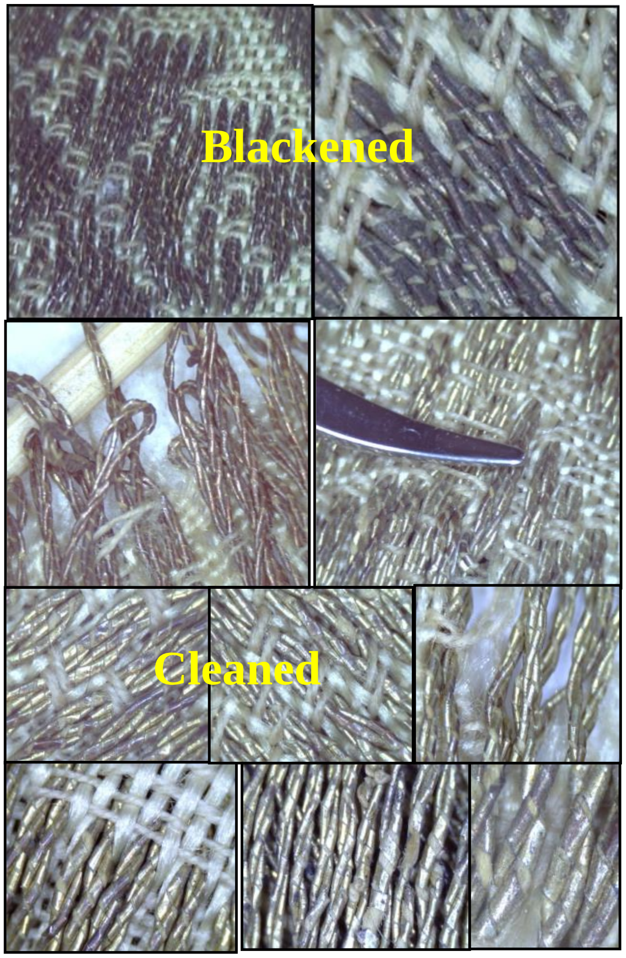

Fig.10. Details of the scaling process of the blackened metal under microscopic inspection(200x); note the blackish colour of the un-cleaned areas, and the brassy golden colour of the cleaned areas being back again.

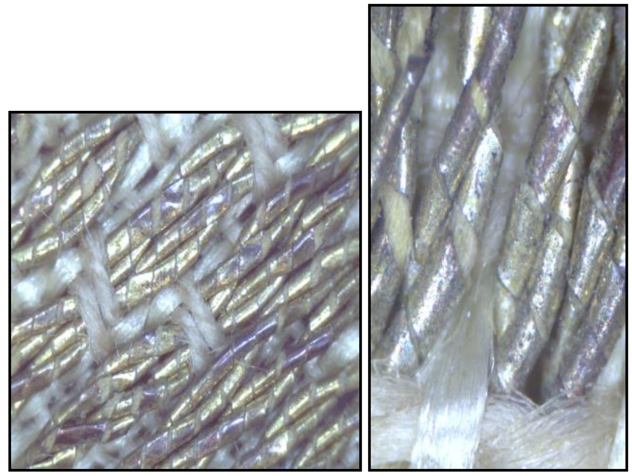

Fig.11.the brassy colour of golden threads showed brightness again.

Fig.12. the decorative patterns of metal thread's after cleaning

3. Results& Discussion

3.1. Examination & Analysis of the case study

The studied object was attributed to about 17-18th century AD (11th - 12th century A.H).It was suggested to be an embroidered fabric probably used as a tablecloth or a lining or awnings (shamianas), to cover both thrones and cushions and even to be used as carpets (Hoke, E. and Heim-Petrascheck, I., 1977), (The Arts of Islam, the Metropolitan Museum of Art, 1981).Many degradation aspects were visually noticed whether for ground fabric or metal threads. The embroidered fabric totally suffered from general embrittlement condition due to poor storage condition; particularly in the ground fabric due to the load caused by the metal threads on the fabric(Balázsy, Á.T., Eastop, D.,1998,28) in the form of splits, friable metal threads. The ground fabric which held the embroidery is weaved from warp yarns which detected to be cotton, and silk as weft in a fascinating hand embroidery technique, as shown from the back of the case study ”knots”. The metal strips were wrapped upon a fibrous core to make up the metal thread morphology. the fibrous core showed the kidney/lima bean grains which proved to cotton .regarding the composition analysis of metal strip showed to be copper-based alloy as Cu, Ag, Au, Ca, Pb, Zn, Si, Cl. Copper as a major element, silver, and other trace elements(table 1).

Table 1. EDS analysis of the mounted specimen of the metal thread.

Analysed area	Metal strip composition
Cu	**75.28**
Au	**1.05**
Ag	**0.66**
Al	**1.07**
Si	**2.62**
S	**3.66**
Cl	**14.61**
K	**o.13**
Ca	**o.13**
Fe	**0.11**
As	0.31

These minute ratios of minor and trace elements were interpreted as additions which the manufacturer may add them as a kind of improving the properties of the alloy. Tiny ratios of chloride "Cl" and sulphur "S' were also detected to confirm the presence of "black spots" and the chlorides attack due to the corrosion occurred. the reasonable amount of sulfur” S” to be 3.66 for this specimen.this percentage gave rise to the occurring blackening on metal threads (Duncan et al)(Weichert, et al.2004).sulfur sources were stated to be from many sources as air pollutant and poor storage conditions.

Microscopic investigation showed that the etched sample showed bright areas on the both side of the strip. It confirmed that the metal strip was double-sided gilded. It was probably found that the gilding by hammering was the applied technique for the metal strips in this case study.Thus gold may have been lost from the surface due to abrasion or delamination (Peranteau, A., *et al*., 1989, 28).

Regarding the black corrosion products, the Covellite "Cu S", Cupric Sulphide it is justified for the present blackening or tarnishing which covered the most of the embroidery. That compound resulted in what is called "black spots". Paratacamite $Cu_2(0H_3)Cl$, a Basic Cupric Chloride, which constitutes one form of the chlorides which represents the most stable phase of the active corrosion "Cl ion"(Scott, D.,2002).

3.2. UDS Scaling

Within the ultrasonic scaler (UDS), cleaning process was successfully attained. Within the concerned parameters, e.g. potentials (power levels) as dominant variable factor, the cleaning task was accomplished. Power range 3, 3-4, 4 with full press of the attached pedal unit, with other constant parameters attributed to the technical specification of the used model. The vibrational action of the scaling tips helped to lessen the blackening and minute corrosion layers as possible. Controllability and flexibility accompanied ultrasonic cleaning process. The fundamental mechanism involved supposed to be the mechanical one; as mechanical forces due to the vibrational actions between the scaling tip and the metal surface would take place. Some localised thermal spots that fade out as soon as the cleaning process is halted may occur. So, it can be speculated how scant damage; if none, can be minimized by giving Short breaks during work is necessary to allow the generated heat of the involved scaling tips to be enough diminished to be ready to complete the cleaning process to and to cool tip down in ethyl alcohol (as proposed here). This mid-range power seemed appropriate for gradually lessening the existing blackening and keeping what remained from bright gilding intact. this mid-range is calculated to be 7.2-9.3 watts(the ideal power used here for gilded copper-based threads).Microscopic investigation during cleaning in-situ(museum) help monitoring the process and halt the treatment once needed with great controllability and simply adjusted;not exposing the surface to detrimental thermal side-effects that probably occur to the organic fibres or the fibre core inside the metal thread.

4. Conclusion

By and large, ultrasound scaler/probe is a pioneering well-balanced solution in-situ for cleaning such delicate category of cultural heritage.as corroded decorative metals; which decorated most historic fabrics represented a challenging task for keeping the integrity of all involved different materials; each on its own merits. a case study of gilded copper-based alloyed threads was selected to be cleaned under great controllability. Parameters controllability seemed very simple and easy to be adjusted as power, compared to other new techniques that not only involve complications for operating and inefficiency as well in most cases. Its small size and availability is of great consideration to be highly considered. That currently set in motion working on optimisation of this clinical tool to effectively clean other types and compositions of metal alloys on fabrics.

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Wafaa Anwar Mohamed, PhD, Professor of metal conservation, Conservation Department, Faculty of Archaeology, Cairo University. Her principal interests focus on the conservation of metal objects, examination and conservation of metals, composite artefacts and metal technologies in ancient Egypt. She has been teaching conservation of metals for undergraduate and graduate conservation students and supervises master and doctoral conservation research since 2000, she has many publications in international conferences and journals.

Mai Mohamed Rifai, PhD, Assistant Professor of metal conservation, the Conservation Department, Faculty of Archaeology, Cairo University. Research interest lies in analysis and conservation of metal artefacts with emphasis on copper based alloys.Current research includes green corrosion inhibitors, protective coatings for outdoor metal and daguerreotypes.

Fatmaa El Zahraa Sadat, PhD researcher, Assistant lecturer of metal conservation, the Conservation Department, Faculty of Archaeology, Cairo University. Master thesis dealt with the analysis, conservation of metal embroidered-fabrics and testing non-conventional cleaning methods as laser and ultrasonic scalers. PhD (ongoing) embraces optimisation of cleaning parameters to be applied on multi-forms of metal embroidery.