Estimating the Condition of the Metal Embroidery Threads in Ottoman Textiles in Al-Manyal Palace Museum in Cairo

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Abstract: *The condition of an object plays a fundamental role in selecting materials and methods that can be used in its conservation. Estimating the condition of metal embroidery threads requires investigation of the technique, composition and deterioration of these threads. This study aims to investigate some selected metal embroidery threads to understand their nature and condition to help conservators develop methods for their conservation. In this study various deteriorating metal embroidery thread samples obtained from Al-Manyal Palace Museum, Cairo, have been investigated using noninvasive methods. The results show that there are different types of metal embroidery threads in the investigated textile samples. The following types of metal embroideries were identified: metal strips spun around a fiber core (cotton), metal strips, wires and metal coils. All investigated metal embroideries in our case study are badly damaged and corroded in various ways. The metal embroideries are also dirty, broken, corroded and riddled with corrosion pits. There is a necessity for the conservation of these metal threads, and it is necessary to carry out further research to investigate and determine the most appropriate and effective approaches and methods for conservation of metal embroideries in textile objects in Al-Manyal Palace Museum, Cairo.*

1. INTRODUCTION

In the past, metals have been used as a raw material in textiles, especially for ceremonial objects or textiles of symbolic meaning. The fabrication of metallic filaments may be traced back to the 3rd century BC in the Middle East (Darrah, 1987). In the Ottoman period textile industry was one of the main economic activities. Ottoman art first appeared in Egypt during the fifteenth century and was in continual evolution during the reign of the Ottoman Sultans. This art was established on an independent basis which meant it was affected from time to time by oriental and western methods. The Persians and the Italians participated in making designs on the embroidered Turkish textiles (Nasr, 2000). The earliest metal threads were thin gilded metal strips which were cut from a beaten metal foil and directly woven or embroidered into textiles. Later these strips were wound around a fibrous core to introduce more flexibility to the thread and make it more versatile (Hacke, et al, 2004). Different techniques of manufacturing the filaments such as hammering, high-speed casting have been developed. A gilded wire was commonly used for high-class manufacturing in the 15th century in Europe both for weaving and embroidery. However, all types of filament may be used in their original form or spun on a fiber core to produce a metal thread. The thickness of the fiber core determines the fineness of the thread (Lee, et al, 2003). The typical structure of metal threads consists of metal strips wound around a silk or cotton core. Metal strips can be made of pure gold, gold alloyed with silver, gilded or gild-silvered copper and gold-like copper alloys. Three metals and the alloy of copper and zinc (brass) were used almost exclusively until the nineteenth century: they were gold, silver and copper. Textiles from recent times have used metal threads made of alloys of copper with various metals, as well as aluminum (Timar-Balazy and Eastop, 1998).

Metal threads can deteriorate and corrode due to different deterioration factors such as higher relative humidity, air pollutants and temperature extremes (NPS Museum Handbook, Part I (2002). Direct chemical reactions, rather than reactions of the electrochemical cell, are responsible for the deterioration of metals by high-temperature corrosion. The actual temperature at which corrosion occurs depends upon the material and the environment, but corrosion usually starts when temperature is within approximately 30 to 40% of the alloy's melting point (Jacobson, 2006). Silver molecules will combine with certain other elements for which they have an affinity to create a corrosion product which we call tarnish. Sulfurs are the strongest tarnishing agents, as anyone who has eaten an egg with a silver spoon or fork will know. But sulfurs are also present as pollutants in the air from the burning of fossil fuels, and are even generated in our homes from such products as foam rubber, carpet padding, paints and wool (Bishop, 2006). Textiles embroidering with metal are generally in poorer condition than those which do not contain metal because of the extra stresses from the high mass of the material and the multiplicity of the degradation processes. The condition of the metal embroidered threads depends on the quality of the materials and manufacturing technique, the natural ageing processes, and the conditions in which they have been treated and kept. Because of the combination of metals and organic fibers, the conservation of textiles containing metal threads presents a variety of problems to conservators (Lee, et al, 2003).

To be able to suggest any conservation intervention plan it is necessary to assess the level of decay of an object and to return it as closely as possible to its original form so that the object may reflect the original artistic concept. The standard preliminary procedure in carrying out this mission is to compile a condition report. It contains the object's materials and construction technique and establishes the incompleteness of the object and the changes and decay the object has undergone. In order to create a clearer picture of the object, it may be necessary to carry out analytical research (Consens, 1987). Available are many studies that investigate the technology and materials of metal threads (Jaro, et al, 1990, Bergstrand, et al, 1999, Hacke, et al, 2004, and Peranteau, et al, 2004, Mohamed, 2004, Abdel-Kareem, 2006, Abdel-Kareem and Al-Saad, 2007). Material investigation is a necessary step in the documentation of the properties of the component materials of a composite textile object for estimating its condition and for considering the appropriate conservation treatment (Timmar-Balazsy and Eastop, 1998).

Al-Manyal Palace Museum in Cairo has a rich collection of textiles decorated with embroidered metal threads, which are an important part of the cultural heritage. This museum is considered one of the most important historic museums in Egypt and contains rare collections of embroidered textiles. This study aims to investigate the embroidered metal threads in textile objects in Al-Manyal Palace Museum to understand their nature and condition and thereby help conservators develop methods for their conservation. Investigating methods should be noninvasive to save the metal embroidery threads which are very rare (Al-Manyal Palace Museum 2006).

2. Experimental

2.1 Ancient Samples: To be non-invasive to the objects, very small meal thread samples were collected from loose threads of different deteriorated metal embroidered threads. These samples were very small: each one was about

2 mm in length. The tested metal embroidered thread samples were collected from 6 various Ottoman textile objects from Al-Manyal Palace Museum in Cairo. The selected samples were collected from various places in the museum to give indication about the condition of all metal threads in these places (see table 1). Then the investigations were carried out on each of the samples separately according to each investigation procedures, as it is described below.

Table 1: Selected historical objects

Object No.	No. of Object in the Museum	Place
1	117	The Private Museum
2	170	Reception Hall
3	46	The Private Museum
4	112	Throne Hall
5	43	The Residence Palace
6	707	Ceremony Room

2.2. Morphological Investigations: Scanning Electron Microscope (SEM) can provide further details on the manufactures technique, the state and the condition of the metal, and the corrosion products can be observed (Jaro, et al, 1990). In this study the SEM investigation was carried out for each type of metal thread among all the collected and tested samples. A SEM Model QUANTA 200 with an EDX Unit attached, with accelerating voltage 30 K.V., magnification 10X up to 4000X and resolution for W. (3.5 nm) (Geology Dept., Faculty of Sciences, Yarmouk University) was used for these investigations. The surface morphology of the textile samples was investigated on very small samples.

2.3. Analysis of Chemical Composition: Scanning electron microscopy coupled with energy dispersive X-ray analysis (SEM-EDX) has been applied to investigate the bulk and the surface metal alloy contents and corrosion products. These techniques have been used previously to investigate metal threads and provided a powerful approach to characterize the surface and subsurface composition (Jaro, et al, 1990, Hacke, et al, 2003, Hacke, et al, 2004, Abdel-Kareem, 2006, Abdel-Kareem and Al-Saad, 2007). Using this technique the semi-quantitative analysis of the elements in the metal threads can be known. Examining the surface and the cross-section of the samples can give information about the main composition

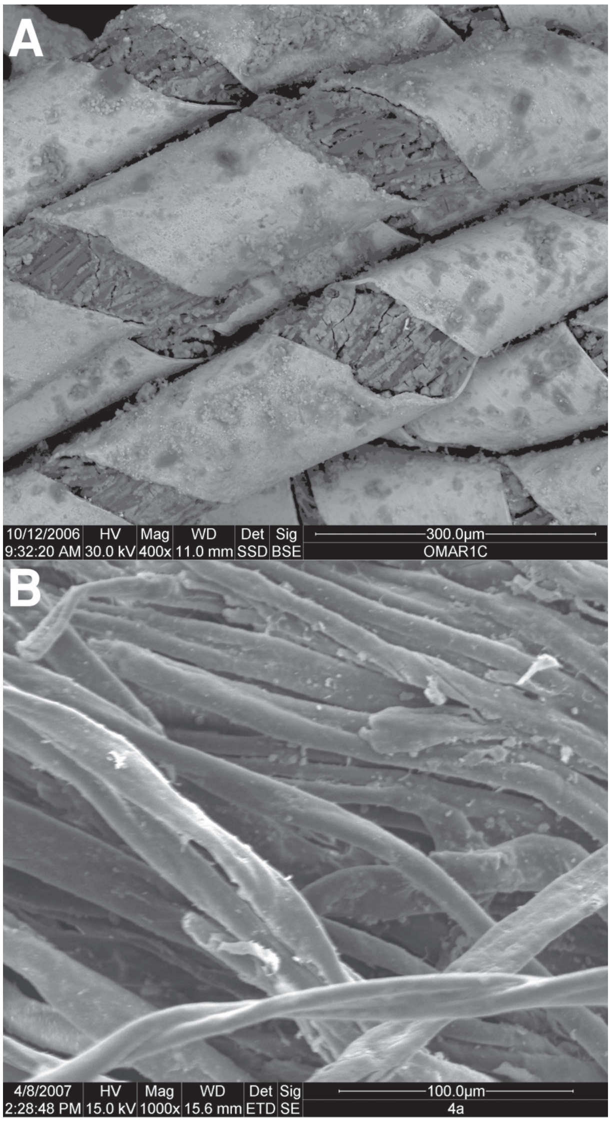

Fig. 1: SEM Photographs of a metal embroidery thread taken from object 1; A) metal strips; B) cotton fiber core

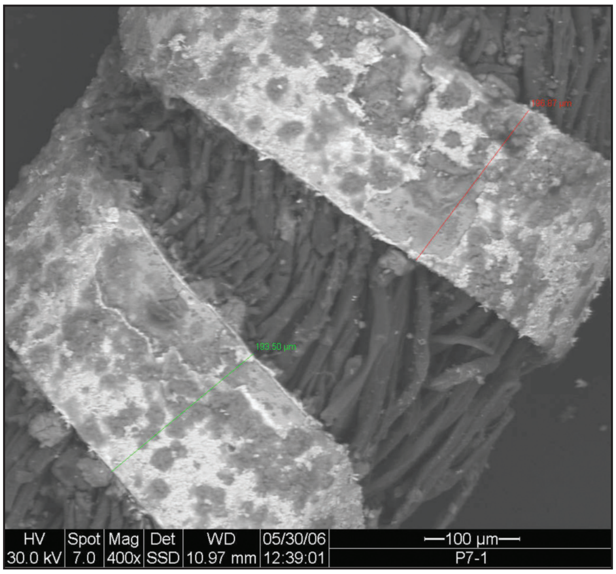

Fig. 2: SEM Photograph of a metal embroidery thread taken from object 2

of the metal threads and the corrosion products that may be present. In this study the samples were mounted on carbon stubs using adhesive-coated carbon discs and then investigated using SEM attached with EDX Unit.

3. Results and Discussion

3.1. Morphological Investigation: The results of the SEM morphological examination of the embroidered metal threads in object 1 show that the metal thread in this object was made of metal strips wound around a fibrous core of cotton fiber yarn (see figure 1). The width of the strip is about 0.2 mm while the thread thickness is about 0.12 to 0.2 mm. The twisting direction of the strip wound around the fiber core is a clockwise, that is a 'Z' twist. The strip has been taken (cut) from a thin metal foil as it is noticed that there are obvious signs in the sample edges of the cutting tool used for making the strip from metal foil. Also the results show that there is a thick corrosion layer on the surface of the metal strips. There are obvious signs of the damage in the metal strip since it is broken and corroded.

The results of SEM morphological examination of metal threads in object 2 show that the metal thread in this object was also made of metal strips wound around a fibrous core of cotton fiber yarn. The width of the strip is about 0.14 mm while its thickness is about 0.39 mm. The twisting direction of the strip wound around the fiber core is a clockwise 'Z'. The strip may have been made by cutting from a thin metal foil as there are obvious signs in the edges of the sample (see figure 2 which show the effects of the cutting tool used for making the strip from metal foil). The examinations show that the strips had been attacked and deteriorated. There is a thick layer of corrosion products covering the whole surface of the metal strips. There are obvious signs of the damages in the metal strip since it is broken and corroded, and there are a lot of corrosion pits.

The results of SEM morphological examination of metal threads in object 3 show that the metal threads were made of metal strips wound around a fibrous core of cotton fiber yarn. The width of the strip is about 0.17 mm while the fiber thickness is about 0.47 mm. The twisting direction of the strip wounded around the fiber core is a clockwise 'Z'. The strip may have been made by cutting from a thin metal

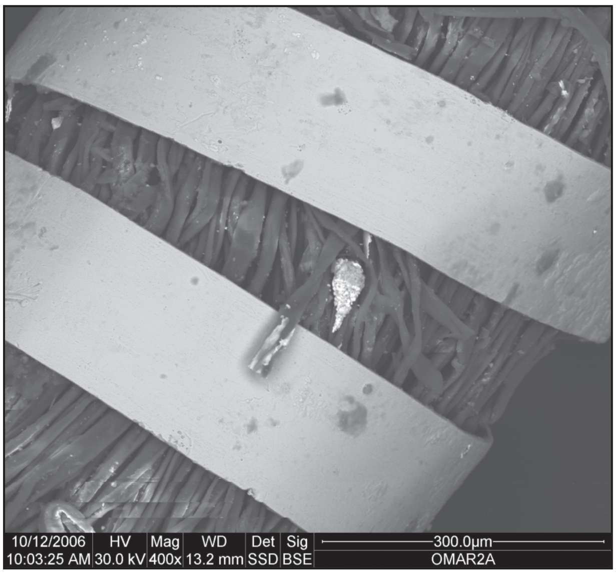

Fig. 3: SEM Photograph of a metal embroidery thread taken from object 3

foil as there are obvious signs in the sample edges (see figure 3 which shows the effects of the cutting tool used for making the strip from metal foil). Also the examinations show that the strips had been attacked and deteriorated. There is a thin layer of corrosion products covering the whole surface of the metal strip. Also it is obvious that there some areas of the surface are covered with a thick layer of corrosion crusts. In general this sample presents the least damage in the surface compared to all tested samples.

The results of SEM morphological examination of metal threads in object 4 show that the metal thread was made of solid metal strips without fiber core. The width of the strip is about 0.29 mm while the thread thickness is about 1.08 mm. Also the strip may have been made by cutting from a thin metal foil as there are obvious signs in the sample edges (figure 4 shows the effects of the cutting tool used for making the strip from metal foil). Also the results show that the strips had been attacked and deteriorated. A thick layer of corrosion products covers the whole surface of the metal strips. There are obvious signs of the damage in the metal stripe as it is broken and corroded and

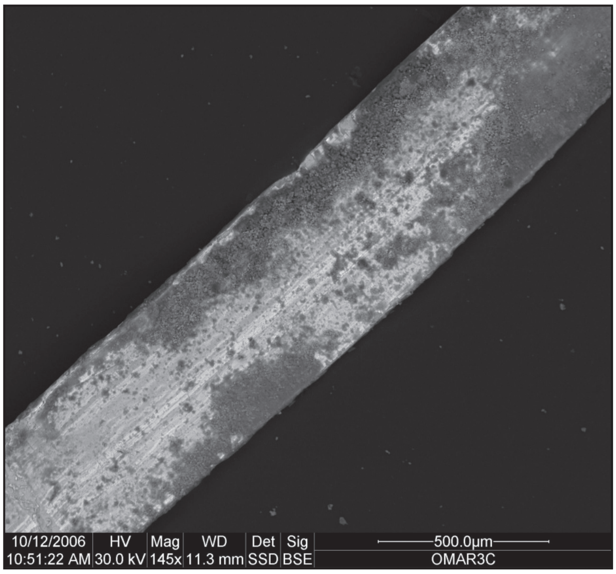

Fig. 4: SEM Photograph of a metal embroidery thread taken from object 4

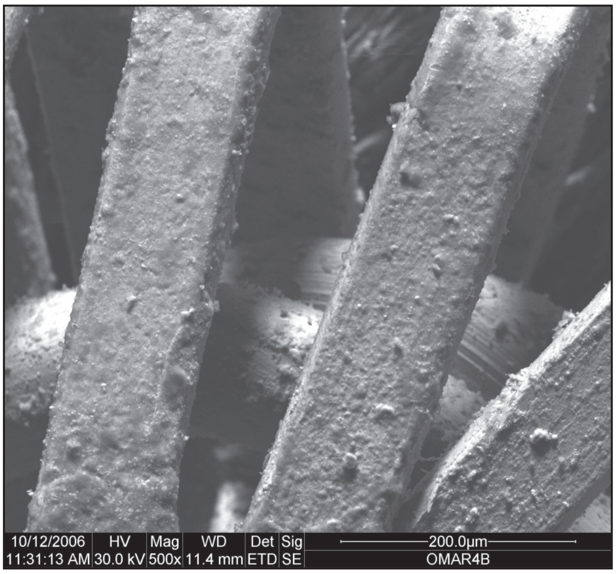

Fig. 5: SEM Photograph of a metal embroidery thread taken from object 5

there are a lot of corrosion pits.

The results of SEM morphological examination of metal threads in object 5, show that the embroidered metals in this object are coils made from wires wound around other wires and fibrous core. The wires are rectangular in section (see figure 5). The width of the wire is about 0.1 mm while the coil width is about 0.71 mm. The wires may have been made by hammering rods, as it is noticed that edges of the wires are rounded but the length and width of the wires are rectangular. Also there are signs of the hammering on the surface of the wires. The examinations show that the wires had been attacked and deteriorated. There is a thick layer of corrosion products covering the whole surface of the metal wires. There are obvious signs of the damages in the metal wires as it is broken and corroded and there are a lot of corrosion pits.

The results of SEM morphological examination of metal threads in object 6 show that the embroidered metals in this object are coils made from wounded wires without a fibrous core. The wires are of a rectangular shape (see figure 6). The thickness of the wire is about 0.08 mm. The wires may have been made by hammering rods, as it is noticed that edge of the wires are rounded but the length and width of the wires are rectangular. Also there are signs of the hammering on the surface of the wires. The results show that the wires had been attacked and deteriorated. There is a thick layer of corrosion products covering the whole surface of the metal wires. There are obvious signs of damage in the metal wires as it is broken and corroded and there are a lot of corrosion pits. This sample is more degraded and corroded than the previous sample.

3.2. Chemical Analysis: The results of EDX analysis of the chemical composition of the surface and cross section of tested metal embroidery threads are shown in figure 7 and Tables 2-7.

The results of the analysis of the cross section of all tested metal embroidery threads show that most of tested metal threads were manufactured from copper coated with alloy metal composed of copper (Cu), silver (Ag) and gold (Au). The results show that the main components of most of tested samples are copper (Cu), silver (Ag) and gold (Au). The main element is the copper,

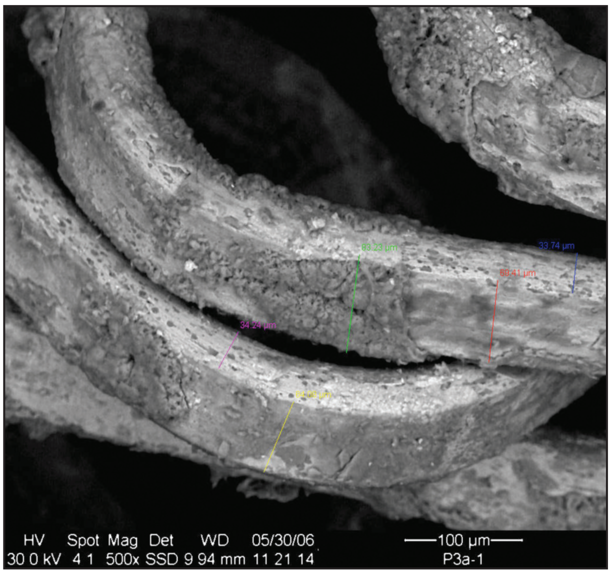

Fig. 6: SEM Photograph of a metal embroidery thread taken from object 6

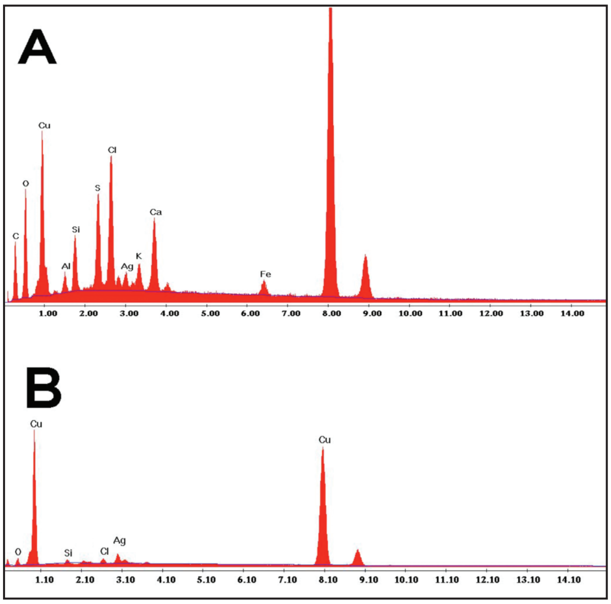

Fig. 7: EDX analysis of the chemical composition of sample 1 A) the sample surface; B) the cross section

accounting for about 90% in most of the tested samples. By comparing the obtained results in figure 7 and tables 2-7 it is clear that the corrosion products are too high on the surface of all tested samples.

Table 2: EDX analysis of the chemical composition Wt % of corroded surface area and cross section of of sample 1

Elements	corroded surface area	Cross section
O	33.88	11.63
Al	1.57	-
Si	3.82	1.55
S	4.53	-
Cl	6.18	1.17
Ag	2.19	5.74
K	1.14	-
Ca	3.17	-
Fe	1.04	-
Cu	42.48	79.91

The results in figure 7 and table 2 show that the surface concentration of contaminant elements such as O, Al, Si, S, Cl, K, Ca and Fe are very high in the metal threads of object 1. The percentage of contaminants is about 56% while the percentages of copper (Cu) and silver (Ag) are about 42% and 2% respectively.

This result confirms that the sample is covered with a thick layer of corrosion products. The metal threads in this object suffer from high deterioration. The contamination elements probably originated from corrosion products and dirt on the surface of metal threads. These corrosion products and dirt that cover the samples may be a result of the higher pollution in the museum in the presence of higher relative humidity (RH) as an effect of plants and closeness to the river Nile.

Table 3: EDX analysis of the chemical composition Wt % of corroded surface area and cross section of of sample 2

Elements	Corroded surface area	Cross section
C	11.77	-
O	32.11	5.37
Al	1.26	-
Si	3.05	-
S	3.66	-
Cl	5.01	-
Ag	1.78	33.01
K	0.94	-
Ca	2.64	-
Fe	0.9	-
Cu	36.88	61.62

The results in table 3 show that the surface concentration of contaminant elements such as C, O, Al, Si, S, Cl, K, Ca and Fe are high in metal threads in object 2. The percentages of copper (Cu) and silver (Ag) are about 37% and 2% respectively while the percentages of contamination elements are about 61%. This result confirms that the sample is covered with a thick layer of corrosion products. This confirms that the metal threads in this object also suffer from high deterioration. The contamination elements are probably derived from corrosion products and dirt on the surface of metal threads. These corrosion products and dirt that cover the samples may be a result of the causes mentioned above.

Table 4: EDX analysis of the chemical composition Wt % of corroded surface area and cross section of of sample 3

Elements	Corroded surface area	Cross section
O	11.06	5.7
Si	0.6	0.53
Au	2.3	1.31
Cl	1.25	0.62
Ag	1.94	2.16
K	0.63	-
Ca	0.46	-
Cu	81.76	89.69

The results in table 4 show that the initial intensities of contamination elements such as O, Si, S, Cl, K, Ca and Fe are not high in metal threads in object 3. The percentages of copper (Cu), silver (Ag) and gold Au are about 82 %, 2% and 2.5% respectively, while the percentage of contamination elements is about 23%. This result confirms that the sample is covered with a thin layer of corrosion products compared with samples 1 and 2. This shows that the metal threads in this object suffer from deterioration too but less than that of the metal threads in objects 1 and 2. This is because this object is displayed in a closed showcase that reduces the effect of both RH and the pollution in the environment surrounding the objects. The obtained contamination elements are probably derived from corrosion products and dirt on the surface of the metal threads.

Table 5: EDX analysis of the chemical composition Wt % of corroded surface area and cross section of of sample 4

Elements	Corroded surface area	Cross section
O	14.71	5.64
Si	1.62	
Au	15.08	3.3
Cl	1.75	0.6
Ag	0.63	1.63
K	0.33	0.34
Ca	0.6	0.32
Fe	0.34	0.49
Cu	59.69	82.98
Zn	5.24	4.7

The results in table 5 show that the surface concentration of contaminant elements such as O, Si, S, Cl, K, Ca and Fe in the metal threads of object 4, are higher than object 3 but less than in objects 1 and 2. The percentages of Cu, Au and Zn are about 60 %, 15%, 5% respectively, while the percentage of contaminant elements is about 20%. This result confirms that this object is covered with a thin layer of corrosion products compared with objects 1 and 2. The metal threads in this object suffer from deterioration but less than the deterioration in samples 1 and 2. This is because this object is displayed in a closed showcase that reduces the effect of both RH and pollution in the environment around the objects.

The results in table 6 show that the initial intensities of contamination elements such as O, Cl, K and Ca are not high. The percentages of Cu, Au and Ag are about 57%, 15%, and 8% respectively, while the percentage of contaminations is about 20%. This result confirms that object 5 is covered with a thin layer of corrosion products compared with other tested samples. This is because this object is displayed in a closed showcase that reduces the effect of both RH and pollution in the environment surrounding the objects.

Table 6: EDX analysis of the chemical composition Wt % of corroded surface area and cross section of sample 5

Elements	Corroded surface area	Cross section
O	16.66	2.54
Au	14.76	0.4
Cl	3.19	0.71
Ag	7.62	0.58
K	0.51	0.33
Ca	0.64	0.36
Cu	56.61	95.07

The results in table 7 show that the percentages of contaminant elements such as O, Cl, K, Ca and Fe are about 33%. While the percentages of Cu, Zn and Au are about 62.5%, 3%, 2% respectively. This result shows that the sample is covered with a thick layer of corrosion products. This confirms that the metal threads in object 6 suffer from extensive deterioration. The obtained contamination elements are probably derived from corrosion products and dirt on the surface of the metal threads. These corrosion products and dirt that cover the samples may be the result of higher pollution in the museum in the presence of the higher relative humidity (RH) from the effect of plants and closeness to the river Nile.

Table 7: EDX analysis of the chemical composition Wt % of corroded surface area and cross section of of sample 6

Elements	Corroded surface area	Cross section
O	28.35	-
Au	2.34	3.77
Cl	1.2	1.05
Ag	0.4	2.84
K	0.21	-
Ca	1.55	-
Fe	0.52	-
Cu	62.53	92.34
Zn	2.9	-

4. Conclusions

Different types of embroidery metal threads were used in the decoration of the investigated samples. The following types of metal decorations were identified: metal strips spun around an undyed fiber core (cotton) with z twist (from left to right), metal strips, wires and metal coils. The metal strips were made from copper (Cu) as the main component with minor quantities of silver (Ag), gold (Au) and zinc. The other type of thread was identified as a wire made from copper (Cu) and silver (Ag). All investigated metal threads are very damaged and there is a massive loss of the materials. All investigated metal threads, except object 3, are covered with a thick layer of different types of corrosion products. All identified corrosion products, may be the result of higher humidity in the Palace owing to the presence of plants and air pollution in the Palace. Also these corrosion products may be the result of past treatment with alkaline solutions such as the alkaline Rochelle salt solution that was used for cleaning and brightening the metal threads. There is a necessity to conserve these metal embroideries as soon as possible and establish a strategy for displaying them. The results of this study will help conservation scientists, and call for further research to investigate and determine the most appropriate and effective approaches and methods for the conservation of metal embroideries in textile objects in Al-Manyal Palace Museum.

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ملخص: إن حالة أي مادة تلعب دورا أساسيا في اختيار مواد وطرق العناية بها. وتقييم حالة خيوط الوشي المعدني تقتضي تحري أساليبها وتركيبها وتلفياتها. تهدف هذه الدراسة لسبر مجموعة مختارة من خيوط الوشي المعدنية، لإلقاء الضوء على طبيعتها وحالتها؛ وهو يساعد المعنيين بالحفاظ عليها، من خلال تطوير وسائل صيانتها. وقد اعتمدت هذه الدراسة على عيّنات مختارة من خيوط الوشي المعدنية المتآكلة في متحف قصر المنيل في القاهرة، وجرت دراستها باستخدام طرق آمنة غير عدائية (noninvasive). وقد أظهرت النتائج وجود أنواع مختلفة من خيوط الوشي المعدنية في عيّنات المادة المدروسة. وحددت الدراسة الأنواع التالية من خيوط الوشي المعدنية: شرائط معدنية مبرومة على مادة نسيجية (قطنية)، وخيوطاً معدنية رقيقة، وأسلاكاً ولفائف معدنية. إن جميع خيوط الوشي المعدنية التي شملتها هذه الدراسة تعاني من تلف شديد، ومن مختلف أنواع التآكل، كما أنها متسخة ومتكسرة ومتآكلة، وتكسوها حفر التأكسد. ولا شك أن الحفاظ عليها أمر ضروري، كما يتحتم إجراء المزيد من الدراسات لمعرفة وتحديد الطرق المناسبة الأكثر فاعلية، للحفاظ عليها في منسوجاتها في متحف قصر المنيل في القاهرة.

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