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N-Isopropylacry Amide Nanogel for Surface Treatment of Corroded Copper Ornaments associated on Coptic Linen

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Abstract:

This paper presents the role of nano structured composites of N-Isopropylacry Amide Nano-gel as a carrier for increasing the performance of surface cleaning of corroded copper ornaments embroidered to linen artifacts. A novel approach to chemical cleaning by neutral soap, loaded on nano gel carrier, was applied for removing tarnishing of copper ornaments, associated to linen fabric. The accelerated aging was performed on Copper/linen coupons, which were accelerated thermally in humidified and acidic condition. Green patina was formed on the coupons, and the physical and chemical properties of both linen and copper were affected. Visual examination, light microscope, SEM-EDS and FTIR-ATR analysis, and color measurements were used to study the behavior of copper corrosion and undyed linen fabric through accelerated aging tests. Evaluation of the proficiency of the selected material in cleaning and its side effects was discussed. The results demonstrated the significant performance of nanogel in cleaning copper coupons without alteration of its morphological appearance and chemical structure. Stereo photos of treated specimens approved the removal of the green patina layers. Progress achieved by removing the tarnishing, active corroded area was noticed significantly through SEM photos. The experimented nanogel was used for cleaning copper ornaments of Coptic linen which is among the collection of archaeological textiles in the Hurghada museum dated to 18 -19th centuries.

Keywords: Coptic linen – Copper ornaments –Corrosion products– Accelerated aging – Cleaning - N-Isopropylacry Amide Nanogel

1. Introduction:

Linen decorated by metallic threads and ornaments were a unique type among archaeological textiles through the historical ages [1, 2]. Conservation and treatment of these Composite artifacts such as linen/copper was considered a challenge, due to the different behavior of them to degradation factors.in addition to the mutual damage of copper and linen [3]. The original copper is converted to primary or secondary chemical compounds (oxides and chlorides) by the degradation of copper alloy, in which the metallic core is covered by a red-brown copper oxide layer, over that, there is a green layer consisting of copper chlorides, while other archaeological objects are completely mineralized, their shape being retained by the corrosion products [4, 5]. The natural substrate characteristic of current copper and bronze surfaces exposed for deterioration factors contains mainly cuprite and brochantite [6].

Thermal degradation, which aimed to prepare an artificially aged model of copper and linen fabrics similar as possible to the archaeological ones, is a common phenomenon that occurred in most of the historical artifacts [7]. Accelerated aging of the copper coupons in the presence of moisture and catalysts caused the oxidative degradation of cellulose [8]. Thermal aging under specific conditions such as acidic medium may lead to hydrolysis of cellulose into cellulose acids complexes by dissolution or swelling in acid [9, 10]. Hydrolysis and oxidation of cellulose is resulted in a progressive weakening of the physical strength of linen. The influence of the oxidation process leads to the formation and release of the degradation products containing a carbonyl group (C=O) and the double bond (C=C) [11].

Oddy Test used at the British Museum has been refined many times to assess the efficiency of the materials, [12.13]

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Cleaning process is one of the most curative steps through restoration process of textile artifacts, which aims to prolong the life of an object [14]. The difference between removing dirt, dust and removing tarnish by abrasives was critical issues, part of the original surface is lost. Repeated polishing may eventually lead to the loss of decorative figures [15]. Studying various methods for cleaning textiles decorated with metal threads and other ornaments, and assessment of its effects and post-treatment stability, was investigated at the Metropolitan Museum of Art, New York [16]. Many researches addressed mechanical techniques for removal of deteriorated layers, used in decoration of artifacts, such as a hybrid cleaning technique, and CO_2 blasting, which combined with laser processing to significantly cleaning procedure [17]. Nanotechnology is widely used for multiple purposes in conservation of archaeological textiles [18]. The aim of this study is to evaluate efficiency of N-Isopropylacry amide nano gel as a carrier for neutral soap on the removal of corrosion products of metal ornaments associated to compound textile artifacts [19]. The selected material is a thermo-responsive polymer with inverse solubility and a reversible phase transition upon heating [20,21], in addition to its stability in the pH range of 3.80–8.65 at 15–60°C [22, 23].

1. **Materials and methods:**

- Raw linen weaved in 1\1 plain1.
- Coupons of copper ,which composed of 99.8 % purity copper with traces of zinc, as it was the main element of the metal ornaments associated to the Coptic textile 2. as shown in fig.1
-Two beakers.
- Distilled water.
- acetic acid [CH_3COOH].
- N-isoproplaccryamide3 97%, formula $C_6H_{11}NO$, formula weight 113.16 g/mol, as shown in table .1.
- Sodium sulphate powder $Na_2SO_4.10H_2O$

"neutral soap" was mixed with the nano gel by ultrasonic emulsifier-free emulsion method, which depend on the using of water only for dissolving the powder [24]

2. Experimental procedure:

2.1 sampling:

Three groups (each one consisted of three samples) of copper coupons were prepared by cutting squares of equal size (0.3×0.3 m^2). They were covered partly with strips of linen fiber at size (0.04× 0.01 m^2). The weight of copper coupons is 5gm, and linen is 2 gm. Whole coupons were cut to hold them to suspend them from the top through the copper wire on two glasses bakers (one of them filled with deionized water, and another one filled with acetic acid). Taking into consideration that they were cleaned carefully in acetone as well as, the beakers were rinsed with water. They were exposed to Bunsen burner to eliminate any organic residues (see fig.1).

Table.1 Characterization of nanogel material

Name of nanogel	Test	properties	Cleaning procedure
N-Isopropylacry amide 97%	Appearance	Off-white	The cleaning process was undertaken by fine brushes and poultices
	Infrared spectrum	Carbon, nitrogen	
	Solubility	5%in toluene	
	specification	Powder, crystal, flask	
	Product number	415324	

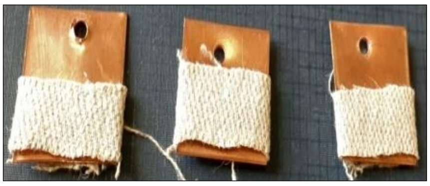

Fig.1 shows the form of one group of the linen strips rolled around copper coupons

2.2 Oddy test aging:

The Oddy test was experimented in 1973 and 1975, by Andrew Oddy, who, developed a replicable testing method to detect corrosion of metals [24]. The Oddy test is a corrosion test in which corrosion induced corrosion of metals at a relative humidity (100%). Specimens were heated in a Shimadzu TGA50 apparatus 4 at 60°C for 28 days [25]. Two types of degradation were done to monitor how the copper/ linen samples react over time. The first step was performed by hanging specimens over glass beaker filled with deionized water to be accelerated thermally in the presence of humidity. The other specimens have a degraded at 60°C of heat for another 28 days fixed over a beaker filled with acetic acid, which is supposed to react with copper in the occurrence of oxygen to form a free radical and an electrochemical corrosion process [26] illustrated its state, as shown in table 2, fig.2.

1 Golden Tex company, Alex, Egypt.
2 The Egyptian Company for Metal Industries, 10 th ramadan, egypt.
3 SIGMA-ALDRICH company, USA
4 Organic materials lab, faculty of archaeology, Fayoum University.

Fig.2 shows the sample 2TC, 2TL, after thermal accelerating and sample 3TAL, 3TAC after thermal accelerating in acidic medium).

Table.2 listed the samples of the experimental study

Sample	symbol
Standard Linen sample	1SL
Standard copper sample	1SC
Linen after thermal ageing	2TL
Copper after thermal ageing	2TC
Linen after thermal ageing in acidic medium	3TAL
Copper after thermal ageing in acidic medium	3TAC
Linen after treatment with nano gel	4NL
Copper after treatment with nano gel	4NC

2.2.3 Cleaning procedure:
N-isopropylacryl amide nano-gel was synthesized via free-radical polymerization, and is readily functionalized making it useful in a variety of applications [27]. Cleaning procedure was performed carefully to remove the darkness and corrosion products from the surface of copper coupons, and cleaning the rusted spotted linen. The research experimented two concentrated of the treated material for 50%, 80% dissolved in water and used it to clean the surface of copper linen samples by poultices and fine brushes. The paper discussed the efficiency rates of removing the rusted and tarnished layer.

3. Analytical Study:
The combination of microscopic investigation such as stereo and SEM microscopes, and analytical techniques such as EDX, colorirmetry measurements have been applied for assessing the efficiency of nano gel in cleaning process.

3. 1 Visual evaluation" stereo microscope":
Aged samples were examined before and after aging and treatment by stereo microscope[5] using Carl Zeiss C-2000 stereomicroscope (Germany) to study the deterioration phenomena that visually happen as a result of accelerated aging, in addition, to evaluate the efficiency of nanogel in cleaning and if it has any future effects in changing morphological appearance [28].

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3.2. Scanning electron microscope coupled with EDX:
The coupon groups were examined by SEM[6] to assess the progress achieved by nanogel material in removing contamination, and undesirable materials on the surface of copper/linen coupons. EDX is an analytical technique, which attached to a scanning electron microscope instrument, and used to determine the chemical composition of materials. The X-ray diffraction can be analyzed with an energy-dispersive system (EDX)[7], by which qualitative and quantitative information was obtained [29].

3. 3. FTIR-ATR analysis:
Using VERTEX 70 Model spectrometer produced by Burker optics technologies Company, Germany, for both Qualitative and Quantitative (for liquid samples) analysis, in the spectral range from 4000 to 400 cm^{-1} without any treatment.[8]

3. 4. Colorirmetry measurements*:*
Changes in the colour of copper coupons were estimated before and after aging, and after treatment, using colorimetric measurement following commission Internationale de l'Eclaraige (CIE) LAB colour system (1976) using a spectro-densitometer (Exact X-Rite, Switzerland) to measure color [30]. Changes on the L* scale (Luminosity), b* scale (yellow/blue colour) and a* scale (red/green color. Five measurements were averaged to obtain one data point. As we need to prove that no changes are happening after applying the nano-material on copper coupons. Repeat scans were completed to check data repeatability.

4. Result:
4. 1. Stereomicroscope:
It was noticed the darkening appearance for both linen (see Fig.3) and tarnshing copper samples after thermal ageing in humidified enviroment, resulted from thermo-chemical aging after production of a copper oxides and copper ions (sulfates, carbonates, and clorides). In addition to accumulate degradation products on the surface of the copper coupons, caused by the continuous oxidation, at high temperature, with the effect of acetic acid evaporated from the beaker [31]. Green-blue patina was formed, which affected on a part of linen sample. Stereo investigation of treated specimens by the nanogel approved its efficiency in removing the most of the green patina, without changing morphological

[6] SEM labs-, faculty of science , Fayoum university.
[7] EDX spectra were obtained at a 10-15 mm working distance and a 25kV accelerating voltage.
8 The ministry of petroleum, Egyptian mineral's authority, central labs.

appearance for both copper and linen fabrics (see in Fig 4.4 and 3.4).

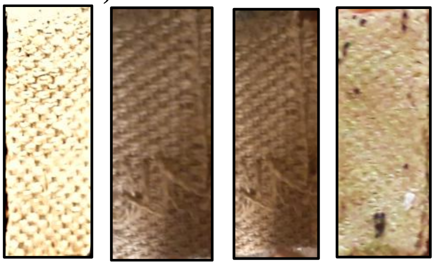


Fig.3 shows the difference between 1SC, 2TC, 3TAC, and 4NC coupons Before and after thermal degradation by heat in the air and an acidic medium for 28 days hanging over distilled water at 60°©, and after cleaning

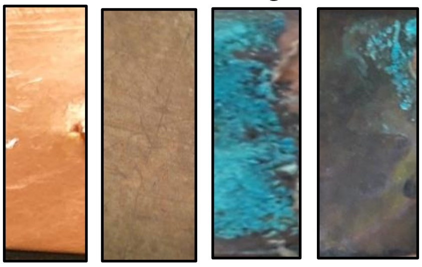
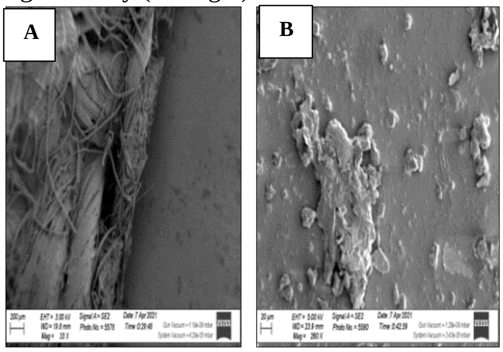


Fig.4 shows the difference between 1SL, 2TL, 3TAL, and 4NL coupons before and after thermal degradation in the humid air and an acidic medium and after cleaning

4.2. Scanning electron microscope:

SEM photos indicated the highly accumulated corrosion products on the surface of the copper, which has bad effects on staining the linen fibers, in addition to deformation of the morphology appearance of linen fibers through the accelerating aging stages, (see fig no 5. A, C). Progress achieved by selected nanogel in removing the tarnishing, active corroded area and undesirable materials deposited on the surface of copper and textile was noticed significantly (see fig.6).



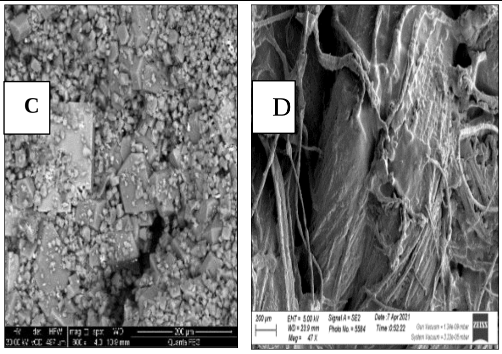


Fig.5A shows SEM images of the region in which the copper is attached to linen fiber, B indicates damage to coupons groups after thermal aging, C indicates the formation of an active corroded area on the surface of copper, D shows the effect of corroded copper on stained the linen fabric

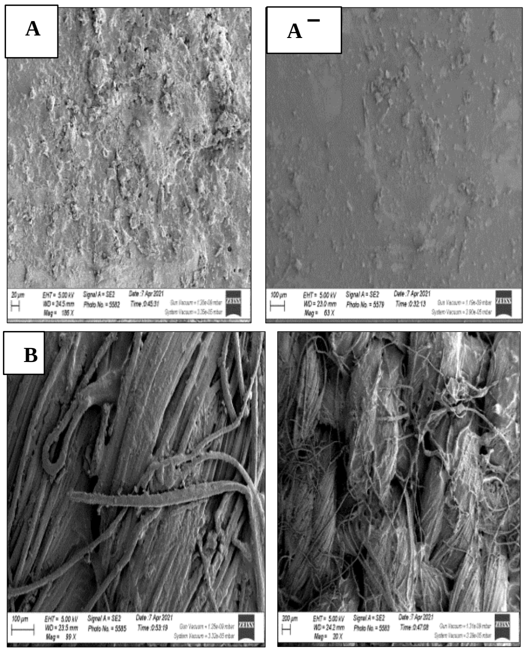


Fig.6 shows SEM images of the achievements obtained after cleaning the coupons of copper and linen with nanogel material, as the of active corroded area disappear in image A¯ and B¯ comparing with image A and B "before treatment

4.3. EDX results:

The results of EDX spot analysis of archaeological corroded copper show the formation of many types of produced elements and reactive compounds, such as oxides, carbonates, chlorides, hydroxyl, chlorides, nitrates, sulphides and sulphates. These identified elements are the major components of corrosion products that existed commonly on copper (see table.2, fig.7).

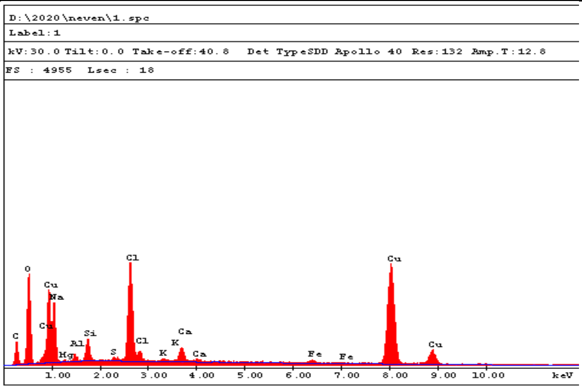


Fig.7 the EDX analysis of deterioration products of copper specimens based on the chloride concentrations, it is suggested that the coupons were most infected by the bronze disease

Table.2 shows the EDX microanalysis of copper aged sample

element	Wt%	At
C k	16.58	30.86
NAk	13.81	13.43
Mgk	0.25	0.23
AL	0.96	0.80
Si	2.49	1.99
S	0.35	0.24
CL	8.70	5.59
Ca	1.30	0.73
Fe	0.52	0.21
Cu	29.35	10.33
O	25.46	35.25

4. 4. FTIR-ATR analysis:

The results provided an overview of the chemical changes that occurred in the coupons samples as a result of the accelerating process. The following bands were corresponding to the standard linen fabric: hydrogen-bonded O-H stretching at ν ≈ 3335 cm-1, the C-H stretching at ν ≈ 2899 cm-1, the –C=C- band at 1632 cm-1the C-H_2 rocking vibration at ν ≈1319 cm-1,-CO- related to peak at ν ≈ 1035 cm^{-1}

The results show changes in the band intensity, after the two accelerating thermal aging processes, for hydrogen-bonded O-H stretching the band intensity change at ν ≈ 3335 cm^{-1} and 3331 cm^{-1}. No significant increase in the band at 2900 cm^{-1} and 2913 cm^{-1}, the band at the 1632 cm^{-1} was disappeared and the C-H_2 vibration at ν ≈1320 cm^{-1} and 1321 cm^{-1}, but the results recorded ν ≈ 1028 cm^{-1} and 1031 cm^{-1}. After treatment, the absorbency of the band intensity at region 1635 cm^{-1}detected a significant change, in addition to the C-O stretching band vibrated at 1023 cm^{-1} after cleaning by nanogel (see Fig.8, table.3).

The other bands were obtained for copper coupons: hydrogen-bonded O-H stretching at ν ≈ 3431 cm^{-1}, which distinguish to $Cu_2(OH)_3Cl$ polymorphs. Atacamite , and anatacamite [33]. The C-H stretching at ν ≈ 2927 cm^{-1}, the –C=C- band at 1637 $cm^{-1}$the C-H_2 vibration at ν ≈1384 cm^{-1}, -CO- related to peak at ≈ 1026 cm^{-1}[34]. Graduated decreasing at C-H stretching band from standard sample to treated sample was indicated. ATR spectra subjected the disappearing of C-H_2 vibration in the two aged and treated samples. Furthermore, the high reading of C-O band intensity for 2TC, 3TAC samples was pointed in (fig.9, table 4).

Table.3 FTIR-ATR collected spectra of linen samples before, after aging, and after cleaning

Functional groups	Samples of 1SL	Sample of 2TL	Sample of 3TAL	Sample of 4NL
O-H stretching	3335	3331	3335	3327
C-H stretching	2899	2900	2913	2902
C=C stretching	1632	-	-	1635
C-H_2 vibration	1319	1320	1321	1320
C-O stretching of v hydroxyl groups	1035	1028	1031	1023

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Table.4. The collected spectra of copper samples before, after aging, and after cleaning

Functional groups	Samples of 1SC	Sample of 2TC	Sample of 3TAC	Sample of 4NC
O-H stretching	3431	3412	3418	3413
C-H stretching	2927	2923	2920	2919
C=C stretching	1637	1627	1628	1630
$C\text{-}H_2$ vibration	1384	-	-	-
C-O stretching of v hydroxyl groups	1026	1040	1044	1036

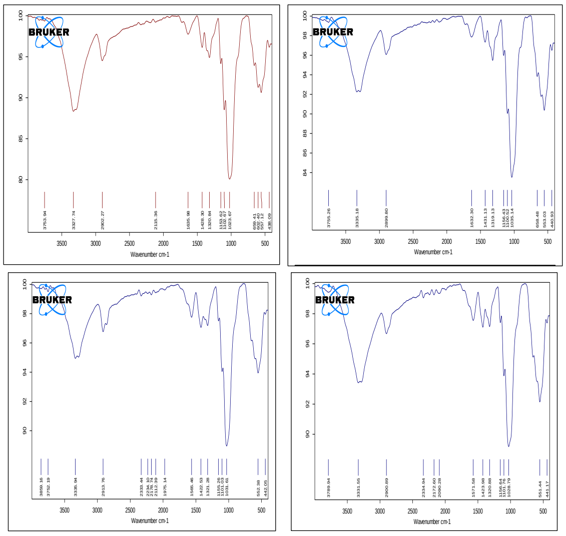

Fig.8 "A" refers to FTIR-ATR spectra of linen sample before and "B, C" for samples after the two stages of thermal accelerating and "D" for treated samples, and there are no significant changes in the absorbance of the band intensity for the most regions

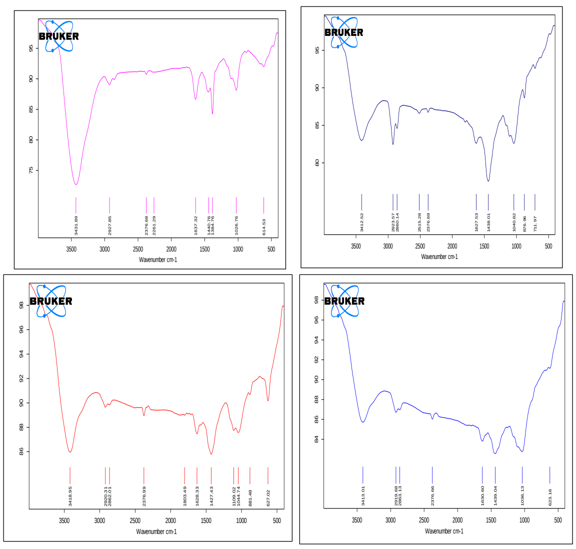

Fig.9. FTIR-ATR spectra of the copper coupons before and after thermal aging, and treatment

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4. 5. Colorimetry measurements:

Colorimetry has become a fundamental field aiming at restoring, preserving, and valorizing artworks, since the beginning of the current century [35]. The colours are located inside a three-dimensional space, the axis of which is “L”, “a”, and “b”. “L” indicates the luminance and can only have positive values from 0 to 100. “a” and “b” are the chromatic characteristics: the first one goes from green to red, the second one from blue to yellow [36,37].

The results of colorimeter measurements proved that there are changes in values of L, a, b for linen-copper coupons, which is considered a good indication of thermal degradation of coupons. Based on that, the darkness of copper specimens after the thermal aging stage was appeared in decreasing the value of L from 28.45 to 20.87 and from 57.95 to 47.69 for linen fiber. Concern copper squares readings of "a" were changed from 17.55, as standard, to 9.47, which means that the color converts to green shades, which interpreted the existence of green layers. On the other hand for linen fiber, the readings of values changed from 6.63 to 14.42 which shows that its color hue converts toward red grades as a result of degradation. The results, after thermal accelerating in acidic media show fading in colorimetric values by increasing the L value from 28.45 to 30.82 for copper squares. Besides, it shows darkness by decreasing in L values from 57.95 to 44.87 for linen fiber. The values of "b" changed from 18.54 to 12.14 for copper squares, although the values of "b" for linen fiber changed from 17.73 to 14.91. Both of them have the same behavior concern degradation, despite the rate of decreasing for copper squares is more than this rate for linen fiber. Reading of color measurements for the active corroded area after total damage record 51.01 for L value, that means the more fading happens, 23.16 for "a" value as a result of forming a greenish malachite layer and values of "b" changed from 18.54 to 11.52. After treatment of the specimens with nano gel materials, the color measurements record the improvement of morphology appearance by changing the value from 51.01" more darkness" to 30.82" less darkness" (see table 5).

Table .5 show the color measurements of the copper and linen specimens before and after treatment

samples	L	A	b
Coupon of copper before accelerating ageing	*28.45*	*17.55*	18.54
Coupon of copper after thermal accelerating aging for 28 days at 60°C	*20.87*	*9.47*	15.69
Corroded area on copper after thermochemical ageing	*51.01*	-23.16	-11.52
Coupon of copper after cleaning by nanogel	*32.50*	*11.83*	12.54
Linen fiber before ageing	*57.95*	*6.63*	17.78
Linen fiber after thermal ageing for 28 days at 60°C	*47.69*	*14.24*	18.20
Linen fibers after thermochemical aging for another 28 days	*44.78*	*4.77*	14.91
Linen fiber after treatment by nanogel	*55.14*	*3.21*	14.46

5. Case study

Applying nanogel in cleaning copper Circular ornaments of Coptic textile:

5.1 Description of the object:

The object is a unique piece among the iconographic Coptic archaeological collection, preserved at the Hurghada museum. The piece dates back to the Coptic period, specifically in 4-6 centuries. It was made by using different techniques, such as tapestry weave, flying weave, and embroidery technique. Decorative regions of the composite object were made of undyed linen, copper ornaments, and copper threads surrounding supported paper, which accelerated naturally. The object was considered a wall hanging, as it looked like an icon with written line consisted of Arabic sentence entitle " **جدد فى عهد ابراهيم المشرقى**" which indicated to the age in which the church is innovated. It is located below the main figure which consists of three regions. The outer one is lined with the monochrome region of silk geometric motifs embroidered by circular copper ornament, as copper isn't found very often pure but plated with gold-silver [38]. The inner region encloses a small central portrait for Virgin Mary surrounded by motifs like the geometric structure of the church, in which cross sign was woven in the two sides and the middle, decoration at the main body of church contained interlaced circle-shaped pattern, bordered by repeated plants figures. At the under edge of the object, there was a decorative line in which the name of the church is written: " الست دميانة "(see fig.10).

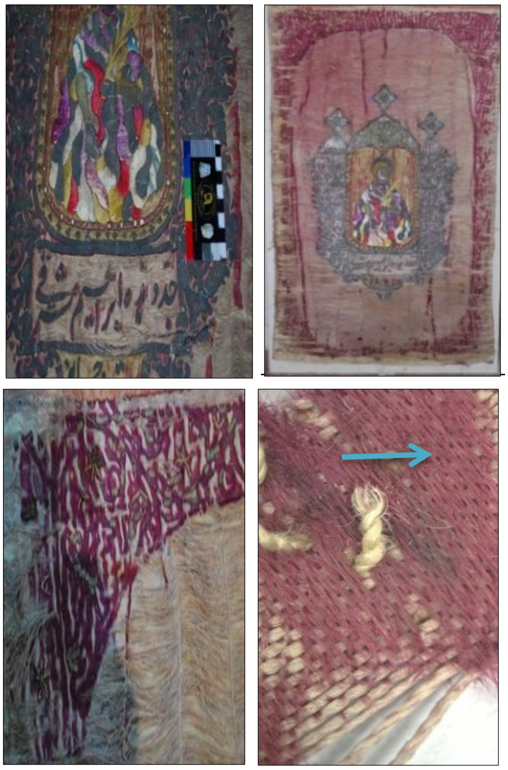

Fig.10 the Coptic object preserved in Hurghada museum, in which silk dyeing yarns used in the weft threads, linen yarns used in the warp threads, and copper ornaments used in decoration

5.2 Technique of the object:

It is noticeable that it was manufactured by complicated techniques, In which various kinds of stitches were used in manufacturing. Such as the usage of cerma technique, as a embroidered technique, that uses metallic threads, or silk threads. Wrapped around stiffness cartoon paper without overlapping the fabric (see fig 11), But only being on the surface of the fabric.in addition to Longitudinal threads of raw linen fixed vertically on red silk fiber by using running stitch in form of horizontal lines, the technique by which the object was made is considered one of the advanced features of Coptic textile through the age 3-6 century, and that proves the dating of the object [39,40].

Fig.11 Running stitch "straight" is used to fix the longitudinal raw linen threads .

5.4. Examination and analytical study:

5.4.1. Visual assessment*:*

Results of the visual assessment revealed that there are many kinds of deterioration phenomena occurring all over the object, such as layered corrosion, missing parts in weft yarns, fading in dyeing yarns, missing many ornaments used in decoration, the darkness of copper ornaments, and loss of the plate parts of threads the gilt silver plated (see fig.12). Many reactions occurred as a result of the thermal degradation, such as chain scission, the production of primary radicals, and the reaction of Macro radicals with oxygen-producing hydroperoxides and other decomposition products [41].

Fig .12. The progress achieved by nanogel in cleaning copper ornaments

6.4.2 X-ray fluorescence spectrometry

X-ray fluorescence spectrometry results identified the chemical structure of the ornament. As, the method allows the quantification of a given element by first measuring the emitted characteristic line intensity and then relating this intensity to elemental concentration [42]. The XRF spectra of metal ornaments proved that they were manufactured of gold-silver copper alloy, in addition to iron as, it provided more strength to the ornaments. The existence of aluminum increases its corrosion resistance due to the formation of the protective layer of alumina, which builds up quickly on the surface after exposure to the corrosive environment [43]. Patination of gilt-silver plated of copper ornaments in vapors is exposed to the impact of chemical solution in a closed environment lead to detach the gilding (see fig.13).

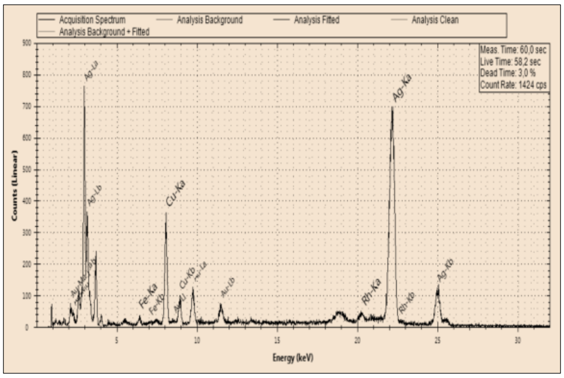

Fig .13 the spectra of XRF show the composites of archaeological copper samples

5.4.3 Cleaning procedure:

It is rare to find a material that can be used for the treatment of composite artifacts composed of linen/copper, nanogel material was used in two concentration of 50%, 80% for cleaning encrustations on the surface of copper circular ornaments of the archeological textile. Through many steps of Brushing corroded copper ornaments. The nanomaterial achieved acceptable success in removing most foreign materials adhering with the surface, and by increasing the concentration of the treated material, the more significant success in cleaning process (see fig14).

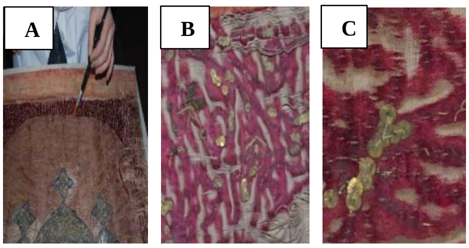

Fig .14 A: the copper ornaments of the Coptic textile before cleaning, B, C: the copper after cleaning by nanogel material

6. Discussion:

The stereo images show the darkness of linen, as a result of thermal degradation [44], and corroding the copper coupons by thermal aging in acidic media, which produced high rates of corrosion with red-brown and green shades [45]. Test procedures and evaluation criteria for the mutual degradation between linen and copper were determined by SEM-EDS and ATR. The results of SEM-EDX indicated that the main components of the tested metal thread are copper (Cu). Both Mg and Fe are the less common element on the surface [46]. High amounts of copper, carbon, and oxygen element covered the copper surface, which may indicate the existence of cuprite "copper oxide" appeared in greenish corrosion appearance [47, 48]. High Temperature is considered the outer manifestation of energy within metal, as chemical decay increases by increasing temperature or relative humidity, forming secondary corrosion products, including cuprite, malachite, and basic copper chlorides [49].

. SEM photos of linen samples refer to the deformation of morphological appearance, as a result of thermal degradation of fiber, when its chemical properties change under the influence of high temperature [50]. While SEM photos of copper coupons indicate to the accumulating layers of corrosion products, appearing on the surface. And also show the efficiency of the N-Isopropylacry Amide Nanogel in removing most of deteriorating layers.

(ATR) the analysis measured the changes that occur in an internally reflected infrared beam when the beam comes into contact with a sample ATR. The spectra of the Cu corroded sample at region (3440–3304 cm^{-1}) attributed to the stretching vibrations of hydroxyl groups, which strongly indicated to the degradation products [51,52]. The region around 1500-1900 cm^{-1} was proved to be the most convenient for the conformations of cellulose degradation [53]. The general common trend for all the control aged samples is the evolution of the broad bands with maxima at around 1730 and1628 cm^{-1} [54]. Comparison between the "L" value between the damaged sample and treated one proved the significant progress, achieved by removing corroded layers by 44%. The readings of color measurement for the aged copper linen samples referred to the darkness of the color hue for both of linen and copper surface, which prove the existence of thermal damage products, even if it was more noticeable on copper surface than linen surface [55]. As result of forming protective dark patina, the value of L decrease from 28.45 to 20.87 after the first stage of ageing, then after the second stage of degradation the reading increases to 51.01 as an evidence of formation of corrosion layers [56] (see table.5).

This study presents an evaluation for nano gel material in cleaning metal ornaments, embroidered to archaeological Coptic textiles, in which parts of gold-silver layers were removed as a result of friction and bad storage. The results prove the efficiency of using nanogel material in removing the corroded layers, deposited on the surface of copper, which appears clearly in the SEM photos and ATR results indicated to decreasing in value of "a" by 10 points compared with standard copper, which means that more green corroded layers were formed. The difference between standard copper and thermal aging specimen of " b " values record 2.69, indicates to convert color hues toward blue color (see table.5). Changing the value from 51.01 to 30.82 means the success achieved in the removal of corroded layers accumulating on the surface of copper. On the other hand, the progress obtained after the treatment of linen fabric represents in returning the color appearance partially to its original state.

Conclusion:

The research proved the efficiency of a neutral soap carried on N-Isopropylacry Amide in cleaning copper ornaments of archaeological embroidered textile. As conservation of composited artifacts was a great challenge, especially for two materials like copper and linen, which have different properties. Thermal degradation of copper and linen samples was chemically and physically discussed. Copper samples were faster in deterioration than linen samples, especially in the existence of humdity, Appearing in accumulated corroed layers. Evaluation of the efficiency of the nanomaterial by using many experimental methods: SEM, stereo microscope, XRD, Color measurements, and ATR was illustrated. Coupons and linen were exposed to two stages of the accelerating process. The result extracted from the microscopic and analysis methods concluded the observable cleaned appearance of the coupons and the object surface after using the nanogel material. Therefore, it is clear that a satisfactory result was achieved. Experimented nano gel material was used by brushes into two concentration for cleaning the copper ornments.

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