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Using the Polymerization of Acrylic Monomers for the Treatment and Conservation of a Historical Piece in the Agricultural Museum, Dokki "An Applied Study"

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Abstract

Textiles should be handled carefully to maintain their integrity. Because handling textile artifacts is a major responsibility, a comprehensive study shall be carried out before making any treatment decision. The proposed treatment should be carried out in cooperation with the concerned disciplines, museum curators, and art historians. It should have accurate steps and be documented and registered to describe the artifact historically or diagnose the damage manifestations using scientific methods, means, tools, and devices. It is important before actual restoration or any treatment steps of the artifact as it shows the pre-restoration steps, demonstrating the success of the treatment operations. Each textile has unique problems that require specific solutions. However, the same principles are applicable, so the methods and materials used must be safe for the artifact, especially in the long run and regenerative [1(Masschelein1993)]. Archaeologists may use polymers in conservation to provide structural support to overcome the fragility and deterioration of the artifacts [2 (Abdel-Maksoud 2010)].

Keywords: archaeologyical ,Silver threads ,Cleaning methods ,Consolidate,Coplymer SEM ,EDX,ATR-FTIR.

Print ISSN: 2785-9533 - Online ISSN: 2785-9541 VOLUME 6, ISSUE 2, 2023, 45 – 69

Introduction

Artifacts, especially textile pieces, are affected by the surrounding environmental factors because of their extreme sensitivity, which causes weakness, fragility, deterioration, and fading of dyes, as well as several damage manifestations. Therefore, many procedures shall be carried out to mitigate the impact of such factors, and conservation and restoration shall be carried out, leading to preventive maintenance in storage halls or museum displays.In order to understand the natural of the material included the making of textile and natural dyes , to definition, the current state of damage accurately, must be used many modern means, methods, and examination and analysis devices for the diagnosis of damage manifestations. Wherefor the current stud used, the USB digital microscope was used, documentation was carried out using a 3D program (AutoCAD), and ATR and EDX were used for biological and microbiological examination . it's for inachieving important results that scientific research seeks to in conservation and restoration primarily aims to successfully consolidation and conserve the textile antique, limit the dangers of the surrounding deterioration factors that may cause further fragility and rupture, and reduce fiber bleeding due to fragility. Using consolidants proved successful in improving the physical, chemical, and morphological characteristics. Moreover, research aims to get rid of stains and dirt as much as possible to restore the piece and highlight its items, including decorative features, natural dyes, and metallic threadsn,Wherefor cleaning is one of the most important stages in the conservation processes of historical textiles[O.Abdel –kareem 2002 ,M.fluy –Lemberg 1988] until museum display, aiming to show the aesthetic and historical values and the scientific importance of such artifacts..the study also applied polymer nano-composites consolidation material to improve the chemical, physical, and morphological properties of the fibers of the textile artifacts of cellulosic origin. **In previous study** synthetic polymers are used by restoration devices to consolidation the artifacts because they show better results compared to their natural counterparts, which may cause many defects 2[(Abdel-Maksoud 2010)]. The most polymers widely used for textile conservation purposes are water dispersed polymers composed of ethylacrylate-co-methylmethacrylate polymers [Timar-Balazsy 1998, O.Abdel –kareem 2005 ,Cocca,M 2006] . copolymer has been show to be effective in preserving archaeological from thermal and light degradation [Rushdya Rabee A,H2017] nano polymers were produced from

Print ISSN: 2785-9533 - Online ISSN: 2785-9541 VOLUME 6, ISSUE 2, 2023, 45 – 69

methylmethacrylate to be used in textile conservation. These nano polymers are Microemulsion copolymers prepared from MMA and MMA/HEMA (having different monomers composition ratios) using Eco-friendly initiation system represented as ultrasonic mechanism Nasr,H.E 2010. All these factors played a major role inachieving the best results of treatment and consolidation . To prepare the piece for the appropriate museum display, the study provided a suitable display method based on sound scientific standards, taking into account adherence to the available preventive maintenance steps. The study was applied to a textile artifact preserved in the Agricultural Museum in Dokki, Giza

Materials and Methods

1. Description of the object

The object understudy is preserved at the Agricultural Museum, the Ministry of Agriculture, Dokki. The museum was established in the palace of Princess Fatima Ismail, daughter of Khedive Ismail, registered under No. 16 of the ninth century, according to the museum's registration and documentation of the object understudy.

It is an overgarment for a woman open from the front. It is likely that it belonged to the Alawite family, according to the place of its preservation. In addition, it has modern features in terms of the style of manufacturing or decoration. The piece is 135 cm long, the back is 40 cm wide, the sleeve is 72 cm long, and the flare is 86 cm wide.

Fibre	Thread count	Direction of the twist	Type of fibers	Color
Warp threads	**Inner lining: 68** **Sleeve lining: 83** **Outer layer: 58**	**Left S**	**Cotton** **Cotton** **Cotton**	**Light beige in all areas**
Weft threads	**Inner lining: 55** **Sleeve lining: 106** **Outer layer: 54**	**Left S** **Right Z**	**Cotton** **Silk** **Silk**	**Beige** **Pink** **Multi colors**

Print ISSN: 2785-9533 - Online ISSN: 2785-9541 VOLUME 6, ISSUE 2, 2023, 45 – 69

2. **Examination of Type Fiber (SEM)**

A Scanning Electron Microscope (SEM) examination of the linear appearance of the warp threads, the weft, the decorative threads, and the metallic threads was carried out to determine the type of fibers and the direction of the twist at the Scanning Electron Microscope Unit, the National Research Center, Dokki, Giza. Samples of small threads were taken from invisible
places and prepared by the unit's technician for microscopic examination by making a golden plate of 24k gold for each sample.

Examination of textile structures(USB Microscope)

The textile structures used in the piece were examined and analyzed using the magnifying lens and USB microscope. The results showed that the weave structure of the inner lining was 1/1 plain. The textile structure used twill weave.

(A) Image of the textile structure using magnification lens

Figure (1)

(B) USB image of the textile structure of the cloth

3. **Analysis of Type Dyes (ATR-FTIR)**

-

Attenuated total reflection (ATR) is widely used to distinguish lots of categories of natural fibers, whether cellulosic or protein. It helps identify and determine the types of dyes, resins, etc. (McCrone 1994). It was used to identify the type of dyes in the fibers. Seven samples were analyzed (5 samples of the decoration threads, a sample of the lining thread, and a sample of the edge decoration threads) to identify the type of dyes in the threads of the object under study.. It was examined by the Supreme Council of Antiquities The device used was (Bruker Vertex 70 ATIR Spectrometer).

Print ISSN: 2785-9533 - Online ISSN: 2785-9541 VOLUME 6, ISSUE 2, 2023, 45 – 69

5. Initial visual examination

The visual examination of the overgarment understudy showed that it was exposed to several deterioration manifestations. This piece had rupture and tear in many different areas throughout the overgarment due to the unscientific display method in the museum exhibition hall. It was fixed with push pins from all directions, diagonally on the wall in the museum's window showroom. Additionally, the museum showrooms do not have the right scientific preparations to display such important historical pieces with various natural decorations and dyes. Despite the efforts of the museum staff to maintain the cleanliness of the exhibition halls, the lack of ideal conditions for the museum display, including adequate temperatures and relative humidity, caused fungal growth due to fluctuations in temperatures and humidity. Additionally, the failure to firmly close the showroom accumulated dust and allowed the infiltration of various types of insects. The lack of regular follow-up of the holdings played a serious role. In addition, the showrooms are exposed to direct light, whether natural daylight or artificial light. All these factors lead to cause many deterioration manifestations.

6. Examination and analysis of the manifestations and causes of damage

6.1 Microbial investigation

The microbial investigation was conducted to identify the types of microbial load in the piece to know if they caused damage or not and to determine the appropriate treatment material and antifungals. Eight samples (swabs) were taken using a special sterile swab from different areas throughout the overgarment.

- Cultivation and fungal isolation

Petri dishes were inoculated (under sterile conditions) with Czapec (dox) agar, which were previously prepared and sterilized. Three replicates (dishes) were made for each sample. Then, the inoculated dishes were put in incubation at a temperature of (28-30 ^{o}C). The medium was Czapec. Moreover, the samples were cultivated in environments suitable for the growth of microbes to know the quality of the microbial load on the archaeological samples.

Print ISSN: 2785-9533 - Online ISSN: 2785-9541 VOLUME 6, ISSUE 2, 2023, 45 – 69

Czapecks medium contained sucrose (30.0 gm), sodium nitrate $NaNo_3$ (2.0 gm), dipotassium phosphate K_2HPO_4 (1.0 gm), aqueous magnesium sulfate $MgSO_4.7H_2O$ (0.5 gm), potassium chloride KCl (0.5 gm), iron sulfate $FeSO_4.7H_2O$ (0.01 gm), agar (15.0 gm), and distilled water (1000 ml) with pH 5.5 - 6. (Chemicals were brought by Sigma and Elgomhouria).

The inoculated dishes were incubated for 7-10 days. After the adequate growth of fungal colonies on this medium, these colonies were taken and purified on new Petri dishes to be re-cultivated on a cellulose agar to show their ability to analyze cellulose; thus, the ability of fungi to do damage. They were prepared and poured into the dishes.

- Cellulose agar medium

Cellulose (30.0 gm), sodium nitrate $NaNo_3$ (2.0 gm), dipotassium phosphate K_2HPO_4 (1.0 gm), aqueous magnesium sulfate $MgSO_4.7H_2O$ (0.5 gm), potassium chloride KCl (0.5 gm), iron sulfate $FeSO_4.7H_2O$ (0.01 gm), agar (15.0 gm), and distilled water (1000 ml)

After that, the new dishes were incubated for a week at a temperature of 28-30°C. After obtaining pure fungal (200) colonies, the purification and identification of the different types of fungi was carried out by studying the morphological characteristics of these purified fungi. They were cultivated on special food media for identification, and their microbial slides were made to identify the morphological characteristics at the Department of Fungi, Microbiology Laboratory, Central Administration for Conservation and Restoration, Center for Research and Conservation of Antiquities.

6.2 Biological investigation

Insects in the inner lining of the piece were identified as molts of moths, according to the report of the Biological Laboratory at the Center of the Antiquities Sector and confirmed by the digital microscope (sub). The moth is one of the pests of linen and woolen textiles and causes erosion of the fibers and holes in the textile. However, investigation showed that this insect did not affect the textile of the overgarment, and only molts were found.

Print ISSN: 2785-9533 - Online ISSN: 2785-9541 VOLUME 6, ISSUE 2, 2023, 45 – 69

Scientific classification:

Order: Coleoptra

Family: Dermestidae

Figure (2)

6.3 Scanning electron microscope (SEM) examination

Diagnosing the condition of the artifacts in terms of damage manifestations resulting from various damage factors causing the deterioration of the fibers is one of the initial important steps to developing a scientific conservation and restoration plan. Therefore, this technique was used. The scanning electron microscopy-energy dispersive X-ray analysis (SEM-EDX) was used to analyze and take photos of the samples of the fibers and metallic silver threads from different areas of the overgarment.

6.4 Energy-dispersive X-ray spectroscopy (EDX)

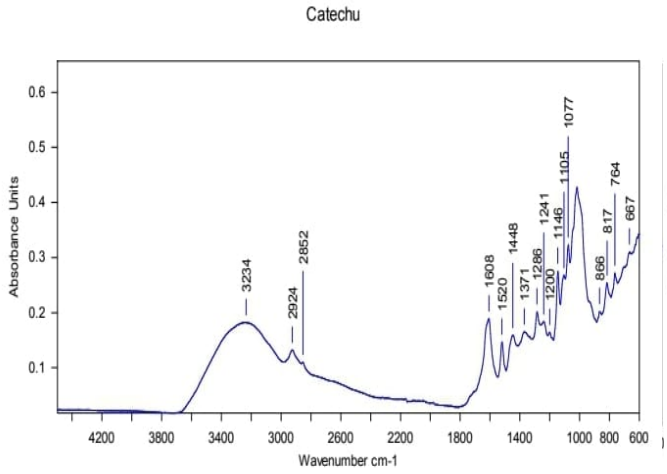
This technique is one of the most important analysis methods that help identify mordants in fibers. (Koestler 1985). We can use it to make quantification of mordants used to solidify the dyes and the chemical elements of the dirt granules accumulated on the surface of the fibers to make appropriate decisions for cleaning and treatment operations.

Print ISSN: 2785-9533 - Online ISSN: 2785-9541 VOLUME 6, ISSUE 2, 2023, 45 – 69

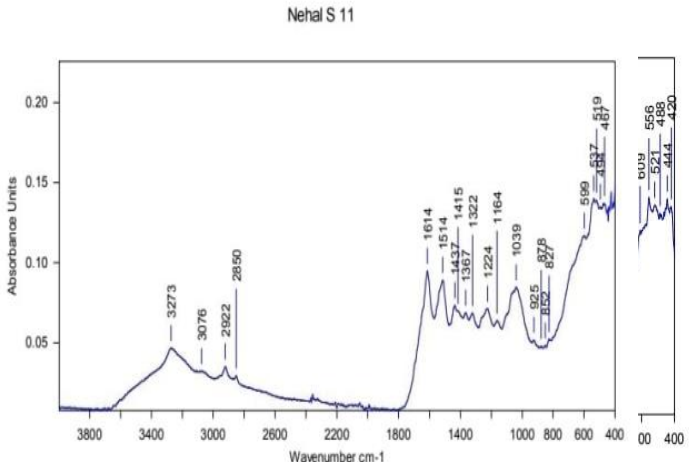
Results and discussion

1. Analysis of Type Dyes results (ATR-FTIR)

The results were obtained by examining the charts resulting from ATR analysis, showing a similarity in the positions of the functional groups in the absorption areas between the archaeological samples that were analyzed and the standard ATR samples at the Center for Research and Maintenance of Antiquities in the Projects Sector, the Supreme Council of Antiquities. The functional groups were divided into two, chromophoric groups that gave color to the molecule (Timar) and the auxochromic group responsible for increasing the color of the molecule.



(4-A) Standard sample of the Indian catechu dye registered in the IR lab (color library)



(4-B) Results of ATR analysis of the first sample of decoration threads (Indian catechu dye)

Figure (3)

Figure (4)

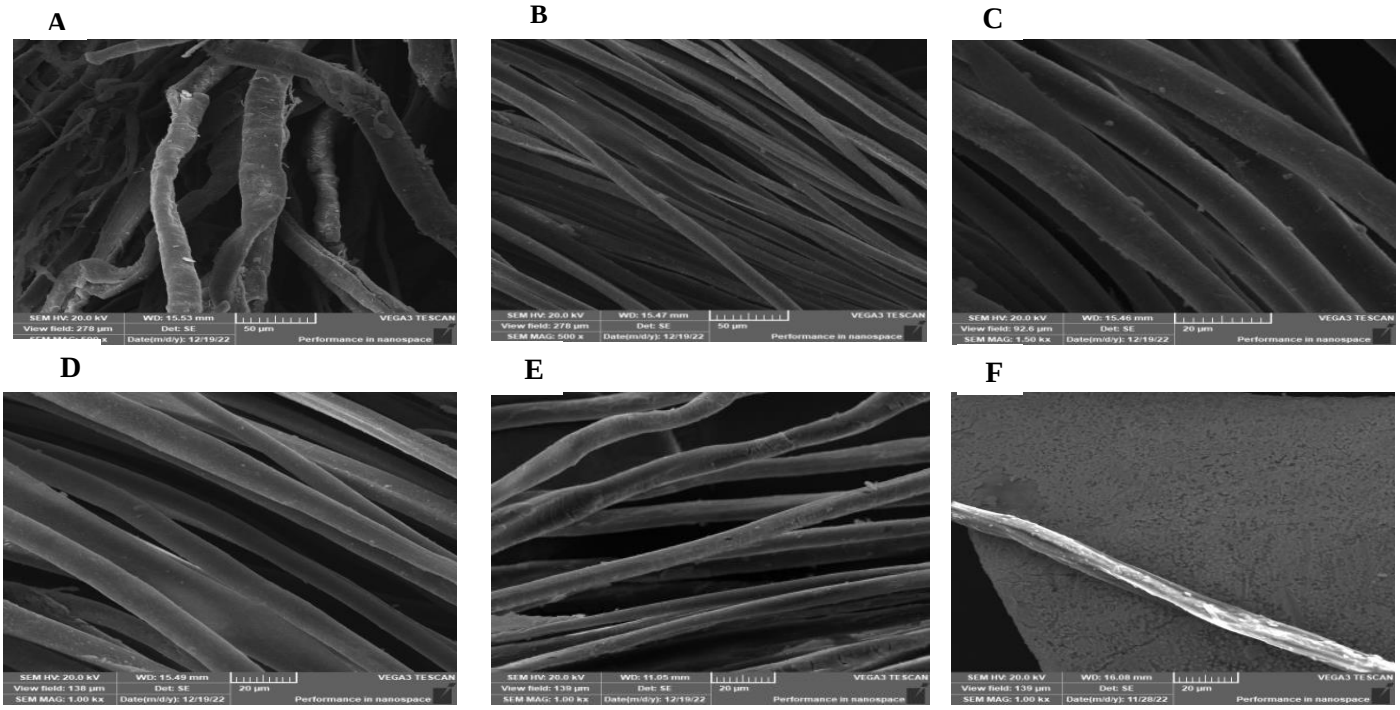
2. Discussion of microbial investigation results(SEM)

Examining the direction of the twist showed that the warp and weft threads of the inner lining were cotton and twisted to the left in the form of the letter (S). Moreover, the decorative threads were made of silk because of their smooth and thin cylindrical shape with the direction of the twist to the right in the form of the letter (Z).

Print ISSN: 2785-9533 - Online ISSN: 2785-9541 VOLUME 6, ISSUE 2, 2023, 45 – 69

It helped identify the condition of the fibers and determine the extent of deterioration, including cracks, surface distortion, dryness, and fragility, which caused breaking fibers.

The cases of deterioration and fragility of the fibers, which appeared clearly in the microscopic



(A) Image of a sample of the textile of the inner lining of the sleeve (×1000) shows that it is cotton.

(B) Image of a sample of the decoration threads (×200) shows that it is silk

(C) Image of a sample of the decorations of the edges (×150) shows that it is silk..

(D) Image of a sample of the textile of the inner lining of the sleeve (×1000) shows that it is cotton.

(E) Image of a sample of silk threads (×1000)

(f) Image of another sample of the decorations of the edges (×1000) shows that it is metallic silver.

Figure (5)

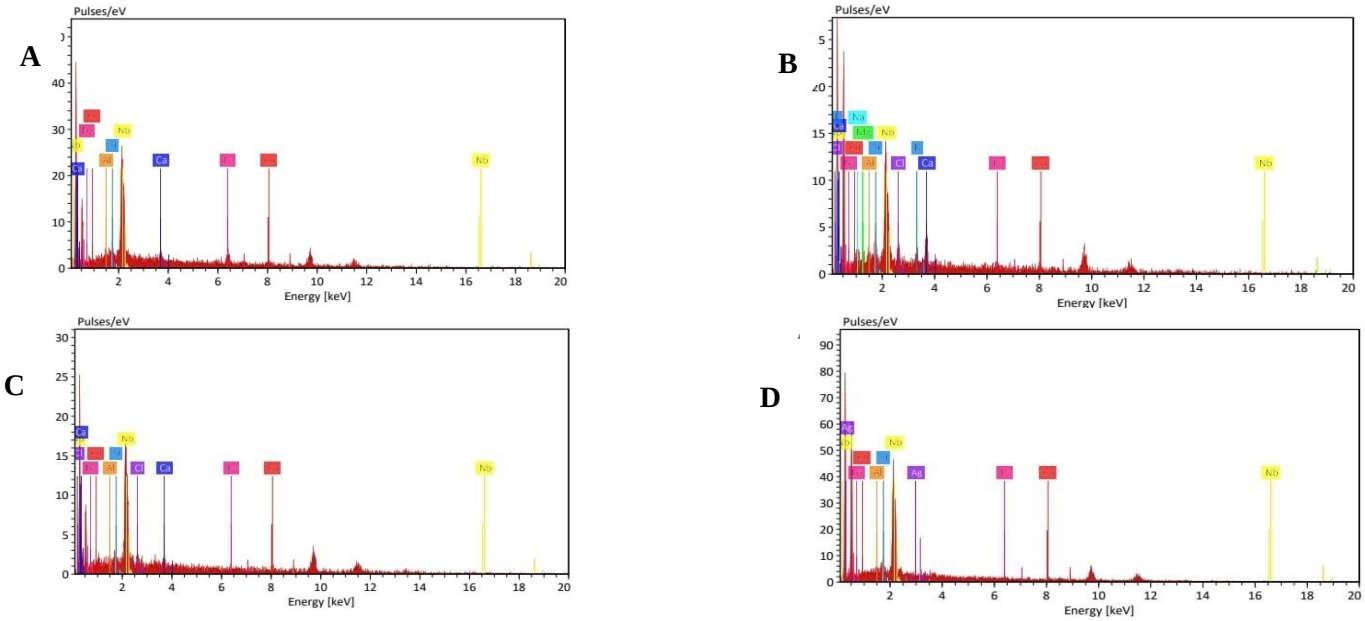
examination, indicated that the overgarment was subjected to a set of physiochemical and photochemical reactions due to the influence of various damage factors, such as light, heat, and humidity, as the main factors that played a major role in influencing the morphological and physical properties of the fibers and caused deterioration, fragility, and a change in the chemical properties.

Print ISSN: 2785-9533 - Online ISSN: 2785-9541

VOLUME 6, ISSUE 2, 2023, 45 – 69

3. Discussion of the analysis results (EDX)

The results revealed the presence of the main and highest element in all fiber samples, i.e., niobium (Nb), followed by aluminum (Al), silicon (Si), calcium (ca), copper (cu), and iron (Fe), which were found in a large percentage in almost all samples. The results revealed other elements in a small percentage in some samples, namely magnesium (Mg), sodium (Na), and potassium (K). All elements are important and penetrate the composition of silicate minerals in the form of calcium and aluminum silicate, which form garnet minerals with a high hardness of (6.5 – 7.5) (Marouf 2004). Moreover, they revealed other elements, e.g., chlorine (Cl), which helped make up dust and dirt particles, in two samples, sulfur (S) in one sample, and silver (Ag) in one sample, that spread in the sample of the powder layer formed on metallic silver threads, supporting the argument that the edge decorations had metallic silver threads. In addition, oxygen (O) and carbon (C) were found in the dust sample of the display.



(A) Results of analyzing elements in sample (1)
(B) Results of analyzing elements in sample (2)
(C)Results of analyzing elements in sample (3)
(D) Results of analyzing elements in sample (4)

Figure (6)

Print ISSN: 2785-9533 - Online ISSN: 2785-9541 VOLUME 6, ISSUE 2, 2023, 45 – 69

4. Discussion of microbial investigation results

Definition and classification showed that the identified fungi consisted of 4 species, which appeared in only 6 swabs .

The microbial investigation of fungi showed that the object understudy contained two species, the most common of which was (Aspergillus) with three different species, the highest was (niger, flavus), and the least was (candidus). The other type, Penicillium sp., appeared in a single swab. These fungi are cellulosic and spread on linen and cotton textile of cellulosic origin. Their species can grow when relative humidity is available (Omar 2010). Historical and ancient textiles are among the most organic materials susceptible to fungal infection in museum collections due to the ability of textiles to absorb moisture from the surrounding museum environment and their chemical structure. Additionally, several factors are a food source for these microorganisms, such as dyes in textiles and surrounding pollutants. This destructive effect of fungi increases on dyed textiles more than on undyed ones. The fungal effect on the materials is divided into two parts: (Katja 2022), (Barbara 2014)

The first part is emitting smelly emission, which characterizes mildew; fungi can affect the aesthetic value of heritage artifacts because of their influence on the morphological characteristics by forming colored and distorted structures on the surface. Color changes are one of the earliest signs that these fungi cause when growing on surfaces, as they can manufacture different dyes in the form of color spots. Fungi produce several types of dyes, some of them cause green or yellow and dark brown to black. Such color spots cause an unacceptable appearance, which distorts and obliterates the original appearance and are difficult to remove. Fungal melanin that causes green and dark brown to black color is a non-degradable polymer of different monomers found in the outer layer of the cell walls of fungi and germs (Katja 2022), (Barbara 2014).

The production of some dyes depends on the species and environmental conditions. For instance, *Aspergillus* has different color dyes:

- *Physcion (yellow)*
- *Erythroglaucin (red)*
- *Flavoglaucin (yellow)*

Print ISSN: 2785-9533 - Online ISSN: 2785-9541 VOLUME 6, ISSUE 2, 2023, 45 – 69

- *Auroglausin (orange- red)*

Therefore, the color spots on the inner lining of the object understudy are probably the result of the influence of fungus because *Aspergillus flavo* causing yellow spots was identified; the color of the spots ranging from yellow to dark brown. Additionally, there were black spots in the underarm area, whose effect appeared inside and outside.

The second part: Fungi can affect the physical and chemical properties of materials due to their continuous metabolic activity, causing structural decomposition of the textile and chemical changes in the fibers, which cause a decrease or loss in the physical characteristics due to the gradual weakening of the tensile strength and elongation ratio (Barbara 2014). Other factors, especially light, play an important and vital role.

Tabel (1)

Number of sample / Fungus	Fungus
1	*Aspergillus niger*
2	*Aspergillus flavus* *Penecillium sp.*
3	*Aspergillus flavus* *Aspergillus niger*
5	*Aspergillus flavus*
6	*Aspergillus candidus*
7	*Aspergillus flavus* *Aspergillus niger*

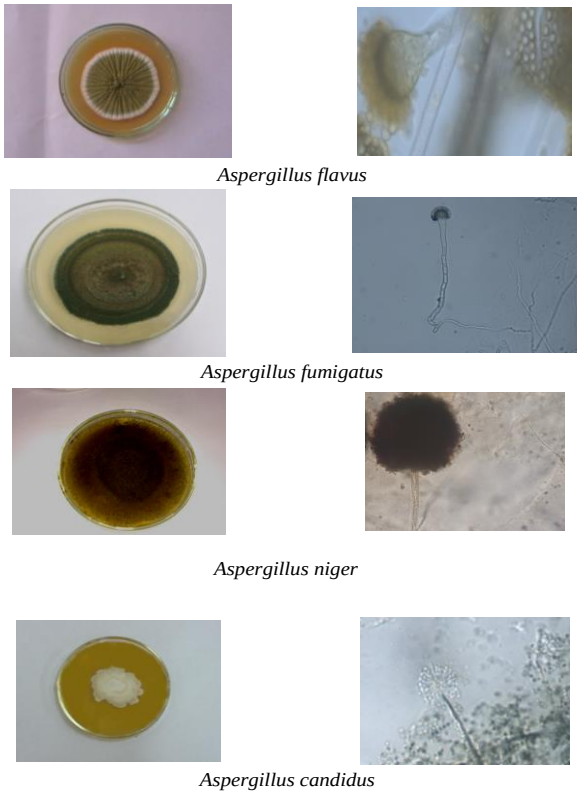


Figure (1)

Print ISSN: 2785-9533 - Online ISSN: 2785-9541 VOLUME 6, ISSUE 2, 2023, 45 – 69

Cleaning

1. Mechanical cleaning

The first step in the actual cleaning begins with cleaning using soft brushes as a kind of mechanical cleaning. Dust and unknown materials shall be removed using brushes with fine protein bristles gently and sensitively without any pressure (King 1985). The object understudy had insect infestations of the carpet beetle, leaving waste, including excretions or eggs and molts. Thus, cleaning using a soft brush was useful (Kumar 2018). A low-power vacuum cleaner was also used. Because the piece had metal threads, they were cleaned to remove the accumulated layer that caused color change, using the microtome attached to the carborundum, Figure (7).

2. Microbiological treatment

This treatment used antifungals for the types identified. Antifungals known for their wide-range effect on some species of cellulose fungi were selected, namely para-chloro-meta-xylenol. Different concentrations were made and tested on previously isolated fungi by doing the test of the clear zone inhibition to measure the fungicidal effect at the lowest possible MIC concentration. The results were as follows:

Tabel (1)

	0.25%	0.5%	1%
Aspergillus niger	+	-	-
Penicillium sp.	+	+	-
Aspergillus flavus	+	-	-
Aspergillus candidus	-	-	-

The table shows that the appropriate concentration is 1% of (para-chloro-meta-xylenol) dissolved in ethyl alcohol of 96% concentration and sprayed on the affected areas and the other parts.

Print ISSN: 2785-9533 - Online ISSN: 2785-9541 VOLUME 6, ISSUE 2, 2023, 45 – 69

3. Wet cleaning

After identifying the types of dirt, the cleaning methods, and the types of detergents, the restorer can start washing the piece to be cleaned in several stages as follows:

- Tools for all stages of wet cleaning

A wooden basin lined with aluminum foil and polyethylene, distilled water (60 liters), synperonic N, materials for rinsing and removing the traces of the detergent (acetic acid), materials for testing the removal of the detergent (phenolphthalein), pH meter, pickers, spray, sampling containers from washing and rinsing basins, filter paper, and blotting paper

- Color fastness test and pH measurement

A. The colorfastness of the piece was tested to identify if it could withstand the washing process in an area at the edge of the piece by:

1- Using a piece of cotton soaked in water and placing the filter paper under the area on which the test was conducted, the result was the color fastness of water.

2- Then, the piece was tested for the color fastness of water and a non-ionic detergent using a piece of cotton moistened with an aqueous solution and a detergent with the filter paper placed behind the area to be tested. The result was the color fastness of water and synperonic N; thus, the color fastness of the piece was confirmed, and it had wash-fastness.

B. pH was measured by soaking the tip of the piece in distilled water with pH 4.3

- **Preparing the piece for washing and preparing the washing basin**

1- The metallic threads of the piece were isolated using Paraloid B-72 dissolved in 3% ethanol (Ahmed2013).

2- Because of the lack of capabilities for washing in the museum, the washing basin was prepared from wood to be bigger than the piece to allow the piece to be moved and raised during washing. Thus, the height of the basin on all its sides was + 5 cm.

3- The floor of the basin was covered with a layer of aluminum foil and another layer of polyethylene to prevent water leakage. Then, a layer of plastic netting mesh was placed as a holder for the piece

Print ISSN: 2785-9533 - Online ISSN: 2785-9541 VOLUME 6, ISSUE 2, 2023, 45 – 69

in the washing basin, and another layer of plastic netting mesh was placed on top of the piece so that the piece became between two layers of the netting mesh.

- Preparing the first wash: (washing basin)

The cleaning compound (synperonic N 1 g/l) was added (Ahmed 2013) to 20 liters of distilled water.

Then, the piece was immersed between the two plastic netting meshes in the cleaning bath and pressed gently from time to time using the brush while turning the piece and moving it at equal intervals in a circular manner. The immersion continued (15-20) 4 minutes. After that, the piece was lifted while keeping an amount of the cleaning solution for measurement operations. Using the pH meter, the pH was 4. Furthermore, phenolphthalein was measured to test removing the detergent traces.

- Preparing the second wash: (the first rinsing basin)

Distilled water (20 liters) was added. Then, the piece was immersed and pressed gently from time to time. The rinsing process took about (10-15) minutes. After that, a sample from the rinsing bath was taken to measure the pH which scored 6.92 and phenolphthalein to test removing the detergent traces.

- Preparing the third wash: (the second rinsing basin)

Distilled water (20 liters) was added. Then, the piece was immersed and pressed gently from time to time. The rinsing process took about (10-15) minutes. After that, a sample from the rinsing bath was taken to measure the pH that scored 7.23 and phenolphthalein to test removing the detergent traces.

- Preparing the fourth wash: (the third rinsing basin)

Distilled water (20 liters) + 5% acetic acid (Marouf 2002) was added to remove the detergent traces. Then, the piece was immersed and pressed gently from time to time. The rinsing process took

Print ISSN: 2785-9533 - Online ISSN: 2785-9541 VOLUME 6, ISSUE 2, 2023, 45 – 69

about (10-15) minutes. After that, a sample from the rinsing bath was taken to measure the pH which scored 7.1 and phenolphthalein to test removing the detergent traces.

- Drying

It is the process of getting rid of excess water in the piece (Tarleton 1995). One of the ideal methods for drying fabric is to use a mesh of gauze or cheesecloth (Pow 1970). Fibers should not remain damp for too long because moisture motivates further microbiological infection and can cause dyes to bleed from the threads (Masschelein 1993)., and the piece was placed between two pieces of cheesecloth and blotting paper alternatively to dry, and they were changed from time to time. The piece was placed between two layers of completely dry blotting paper for the next day, which was adequate for the piece to become completely dry, Figure (8).

4. Chemical cleaning

Dry cleaning was adopted because there were some stain traces after the complete drying of the overgarment, especially in the inner lining. However, the color fastness of any solvent must first be measured, as in wet cleaning. White clean blotting paper was used, and the piece was pressed between two blotting pieces of paper after adding water with the detergent to dilute in appropriate proportions on a small part at the tip of the piece (Pow1970). The organic solvents used included oxalic acid (2% concentration) to remove rust traces (Mohamed 2020), acetic acid, ethyl alcohol, acetone, and ammonia (2% concentration).

Consolidationment, consolidation, and needle sewing fixation

1. Consolidationment and knitting

After completing all the preparations and equipment for this process, each of the areas that need consolidationment was measured separately to make consolidationment pillars using dyed linen, with an area greater than the area to be consolidationd by about 0.5 cm from each side. Consolidationment varied according to the condition of fragility. Then, it was placed taking into account that the warp to be in the direction of the warp and the weft to be in the direction of the

Print ISSN: 2785-9533 - Online ISSN: 2785-9541 VOLUME 6, ISSUE 2, 2023, 45 – 69

weft of the overgarment. The supporting textile pieces were placed as fillings between the outer layer and the inner lining of the overgarment to perform a dual function to strengthen and consolidation the outer layer from the front and strengthen and support the inner lining from the back without deformation or change in appearance. The reinforcing pieces were installed first, at a distance from the fragile area, using continuous stitch. Some areas required using dyed silk threads in a few areas to be inserted horizontally or vertically according to the case of loss. Cylinders of different diameters were utilized to suit the areas to be consolidationd to act as carriers and facilitate consolidationment.

2. Consolidation of the inner lining of the overgarment with acrylic monomers

- Materials : Methyl methacrylate (MMA), hydroxypropyl methacrylate, sodium dodecyl sulphate (SDS), Tio_2 (2% concentration), and acetone

The polymer used in the experimental study, i.e., MMP/ HPMA copolymer, was prepared at a concentration of 5%. Proportions were chosen according to the results of the experimental study that improved the characteristics.

- 35 ml MMP + 15ml HPMA
- 950 ml Acetone
- 0.5 gm SDS
- 1.0 gm Tio_2

Then, using the initiator of the reaction, the Altura sonic device and after a specified time of about 20 minutes, the device was stopped. After that, the polymer was ready for application, as it was applied by painting to consolidate the inner lining only of the object understudy, as it was free of any unknown materials from the type of cotton textiles of cellulosic origin understudy. The ratio that gave the best results was chosen to improve the morphological, chemical, and physical characteristics of the experimental samples. The consolidant was prepared in the same manner as explained in the previous section.

Print ISSN: 2785-9533 - Online ISSN: 2785-9541 VOLUME 6, ISSUE 2, 2023, 45 – 69

3. Consolidation of the outer layer of the overgarment

- Materials

Klucel G

SCMC

Ethyl alcohol

Kulcel G, a hydroxypropyl cellulose, and SCMC, sodium carboxymethylcellulose, belong to the group of non-ionic cellulose ethers with distinctive characteristics, such as solubility in organic solvents and water, so they have the ability to recover. Their films are characterized by good flexibility. Kulcel g can fix other water-soluble cellulose polymers. Its films are characterized by flexibility. It also has good resistance to fungal growth (Omar2010). SCMC has good resistance to pests and fungal attack, as well as anti-shrinkage properties (Cathleen 2010). (Kulcel G 1% + SCMC 1%) was dissolved in the organic solvent ethyl alcohol. The insulation and consolidation material was applied using soft brushing. This consolidant was used for silk threads and metallic threads used in decorations. Each of them differed from the nature of the cotton textiles of cellulosic origin understudy. Therefore, the acrylic monomers of the experimental study of this outer layer were not used.

Museum display of the overgarment understudy

After completing all stages of conservation and consolidationment, it is time for the complementary stage, i.e., preventive maintenance and the safe presentation of the object understudy. Because the piece was not securely displayed, a display was prepared according to standard specifications and sound scientific principles.

1. Display

A special display was prepared according to the standard specifications for a secure museum display to protect the piece with more than 15 cm from the mannequin on all sides. It was made using acrylic plates of high quality and thickness (8 ml) measuring 70x60cm× 185 cm high. It was

Print ISSN: 2785-9533 - Online ISSN: 2785-9541 VOLUME 6, ISSUE 2, 2023, 45 – 69

made by curvature the corners of an acrylic sheet to enhance aesthetics and provide a clear and eye-pleasing vision.

The display had a wooden base with a drawer to put anti-pest materials, and the top surface of the base had 1 cm- holes on spaced and regular distances of up to 5 cm to help in the work of the anti-sept material without a barrier. Paratex and naphthalene were put in Petri dishes and distributed throughout the drawer of the display's base.

2. Mannequin

It was multi-layered to be tough and safe for displaying the overgarment. The first layer was glass, the second was thermal fiber covered with a layer of cotton fabric (gabardine), and the final layer was natural raw linen fabric that was not chemically treated to act as a textile holder for the piece when placed on the mannequin. First, the textile holder was washed using distilled water to get rid of impurities and preparation materials. Then, drying and ironing were carried out to be ready for covering the mannequin. The mannequin had a carrier base, taking the form of a small square box.

3. Museum display

After completing all preparations, the mannequin and the overgarment were displayed in the display, with a hygrometer to measure temperature, humidity, and silica gel in Petri dishes to absorb moisture and distributed on the mannequin under the overgarment in different areas. Moreover, the museum label was added (Figure 9).

4. Modern technology applications in museum display

To achieve the sustainable development strategy to develop an accurate information system on various tourism patterns and maximize the use of modern technology in promoting antiquities, introducing Egyptian sites and museums, and providing tourism services to visitors and tourists, the modern approach for museum display utilizes artificial intelligence and information technology. A QR code was created and put on the display to enable visitors to obtain the

Print ISSN: 2785-9533 - Online ISSN: 2785-9541 VOLUME 6, ISSUE 2, 2023, 45 – 69

information of the piece easily in the form of a video clip, website, images, and cartoon, by scanning the QR code using smartphones. Using QR codes makes exhibitions or museums more interactive and richer in information. The code was designed by the researcher (Figure 8-D).

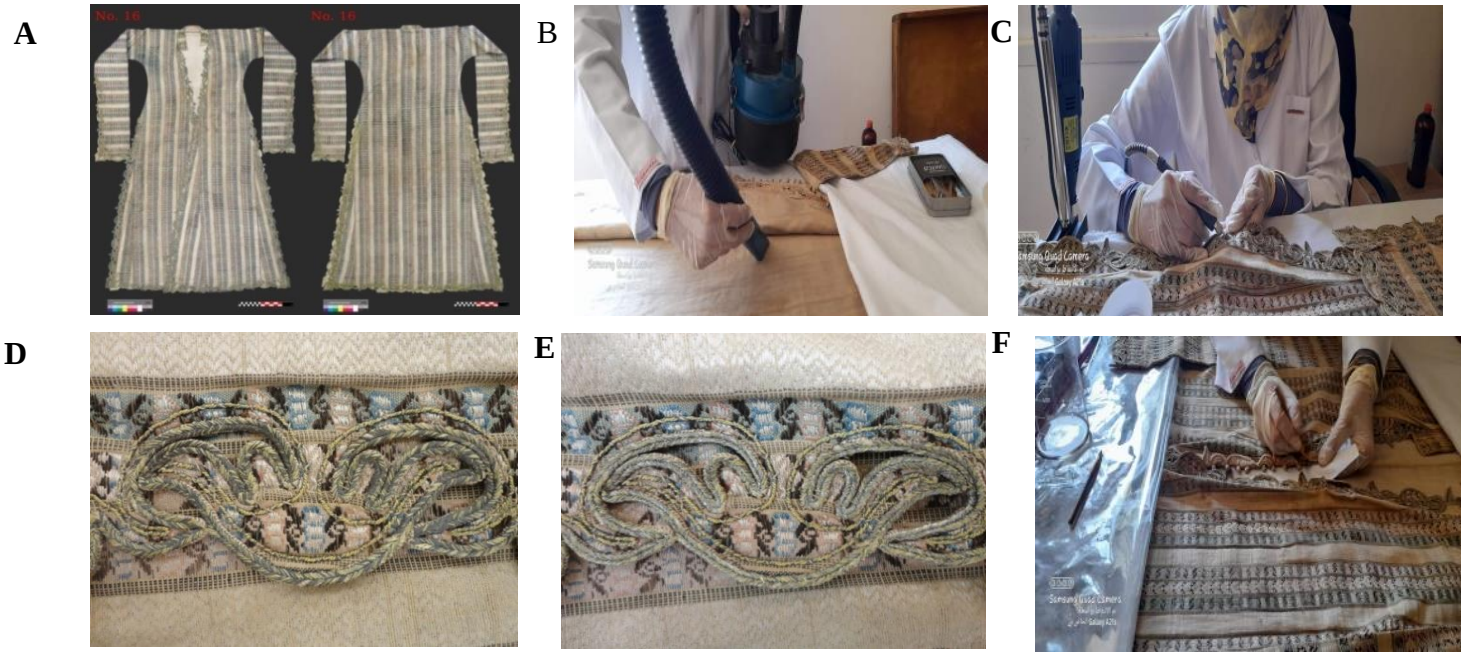


Figure (7)

(A) Image of the front and back of the piece
(B) Image of the chemical cleaning using a low-power vacuum cleaner
(C) Image of cleaning the metallic threads
(D) Image of the metallic threads before cleaning
(E) Image of the metallic threads after cleaning
(F) Image of the isolation of metallic threads

Print ISSN: 2785-9533 - Online ISSN: 2785-9541

VOLUME 6, ISSUE 2, 2023, 45 – 69

A

B

C

D

Figure (8)

(A) Image of the wet cleaning of the piece

(B) Image of drying the piece

(C) Image of the piece after cleaning

(D) QR of the piece.

Print ISSN: 2785-9533 - Online ISSN: 2785-9541

VOLUME 6, ISSUE 2, 2023, 45 – 69

Figure (9)
Image of the piece after museum display in
the prepared display from different angles

Print ISSN: 2785-9533 - Online ISSN: 2785-9541 VOLUME 6, ISSUE 2, 2023, 45 – 69

Conclusions

The study concluded several results based on examinations and analyses to investigate and characterize archaeological textiles. For instance, visual examination illustrated various damage manifestations of the artifact understudy. The USB microscope and SEM showed that the fibers of the inner lining were cotton of plain weave structure 1/1, the outer layer was made of silk fibers, and the decorations were of twill weave. The decorations of edges included metal silver threads. Furthermore, the investigations illustrated the tear, severe weakness, and fiber breakage. ATR-FTIR analysis of the dyes of fibers showed that they contained madder, henna, indigo, and Indian costus. The microbiological study on areas of the piece revealed four fungi species (i.e., Aspergillus niger, Aspergillus flavus, Penecillium sp., and Aspergillus candidus). Additionally, the biological examination of a sample of insect remains in the piece showed that they were molts of beetle. EDX investigation and elemental analysis illustrated a high percentage of chemicals forming the dirt particles accumulated on the surface of the fibers, such as Al, Si, Ca, Cu, and Fe. Utilizing various cleaning, consolidation, and supporting operations and materials, the study could achieve the highest possible protection and consolidation and avoiding the loss of the piece. Also using the supporting textile pieces of dyed linen that matched the fabric of the overgarment understudy played a major role in consolidating fragile areas and highlighting the aesthetics and decorative units of the piece. This success was motivated by several factors, including the accurate selection of stitches and type of threads

Print ISSN: 2785-9533 - Online ISSN: 2785-9541 VOLUME 6, ISSUE 2, 2023, 45 – 69

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