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PAINTED ANCIENT EGYPTIAN MUMMY CLOTH OF KHONSUEMRENEP FROM BAB EL-GASUS EXCAVATION: SCIENTIFIC ANALYSIS AND CONSERVATION STRATEGY

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ABSTRACT

The studied mummy cloth of Khonsuemrenep (a priest and scribe of Amun from the 21st Dynasty), had been excavated in one of the major excavations in Deir El-Bahari in Luxor 1891, the Bab El-Gasus tomb. This research has utilized multi-analytical approaches; including Optical Microscopy, Ultraviolet-Visible (UV-VIS) and Scanning electron microscopy SEM and EDX, Fourier-transform Infrared (FTIR), X-Ray diffraction (XRD), and Portable XRF Spectrometer (PXRF), to examine and identify the fabric characteristics, methods and materials used in the manufacturing of this textile object, assessing its condition, and to explain strategies of conservation processes. The results illustrated that the object fibres are linen in a very poor physical and chemical condition. The painting process had done by using a brush with a black charcoal and Arabic gum without a ground layer. The treatment procedure carried out with the object reflects a conservation strategy that currently in use at the Cairo museum in the stabilisation of fragile ancient Egyptian textiles; which includes the use of efficient low-tech solutions that require little equipment and conservation materials. The techniques are easily applicable and most importantly, remains reversible.

KEYWORDS: Bab El-Gasus Excavation, 21st Dynasty, Mummy Cloth, Conservation, FTIR, SEM, PXRF, Pressure mounting

1. INTRODUCTION

It is clear from the textiles excavated from both tombs and settlement sites that, as early as the predynastic period, the Egyptians were proficient spinners and weavers (Strand, et al., 2010). Information about the textile technology of Pharaonic Egypt derives both from the textiles themselves and from a representation of the various stages of textile production, from the sowing of the flax-seed in the ground to the weaving material (Newberry, et al., 1893). In Ancient Egypt, textiles were used for many purposes, among them clothing, bags, sails, ropes, and nets. The Majority of ancient Egyptian textiles are of linen which is made from the bast fiber, flax. The Egyptians used linen from Pharaonic times onward. Linen was preferred because it is durable and strong (Nicholson, et al., 2000). Egyptian mummies were wrapped in linen because it had been seen as a symbol of light and purity and as a display of wealth. Some of these fabrics, woven from handspun yarns, were extremely fine and the fineness of the threads in them cannot be produced even today on spinning machines (Bowen, 2001). During Pharaonic times the Egyptians didn't use wool because it had been regarded to be ritually unclean. Linen fabrics were also cooler than wool fabrics, which was important within the hot climate of Egypt. However wool became common about the time of ancient Greece and Roman conquest, around 30 B C (Dunn, 2002). Many types of cloth were used in embalming and each had its name, most important in the ritual accompanying the preservation operations of the dead body (Scaevola, et al., 2008). Textiles often present complex structures and represent the highest technological achievements of a culture, but because of their fragile and organic composition, they often don't survive (Shehata, et al., 2020). They are highly vulnerable to damage from light, dirt, airborne pollution, microorganisms, and mechanical damage. All these factors cause debilitating in both fibers and dyes, harden and stain fibers, separates parts and eventually some parts are lost (Ahmed, et al., 2018). They require carefully controlled, reliable temperature and humidity conditions as they are extremely vulnerable to damage when stored or displayed in inappropriate environmental conditions (AL-Gaoudi, 2013). Identifying the properties of a textile object can greatly aid in its caring and conservation. The conservation aims to improve the properties of textile objects and improving their long-term stability. Also, conservation aims to slow down the rate of the further deterioration of textile artefacts as much as possible (Abdel-Kareem, et al., 2010), while relevant analytical works to textiles have been reported recently (Amin 2017, 2028; Karydis et al., 2019).

The paper's objective is to present for first time the strategies of scientific investigations carried out to this mummy cloth of Khonsuemrenep (a priest and scribe of Amun from the 21st Dynasty (1070 BC to 945 BC) which assist in set the strategies of conservation procedures of this textile object. A combined set of multi-analytical methods is used to identify and examine the materials and methods used in the manufacturing of this object, assessing its preservation condition. Methods employed include: portable digital microscope, Ultraviolet-Visible (UV-VIS), Scanning electron microscopy with energy dispersive X-ray spectrometer (SEM-EDS), Fourier-transform Infrared (FTIR), X-Ray powder Diffraction (XRD), and Portable XRF Spectrometer (PXRF).

2. HISTORICAL BACKGROUND OF THE OBJECT

One of the great excavations in Deir El-Bahari found by Grébaut and Daressy in January 1891, which is known as Bab El-Gasus cache or tomb. It is the largest undisturbed tomb ever found in Egypt, discovered just ten years after the 'Royal Cache' (1881) (Weiss, 2018). The tomb was used as a cache for the burials of 153 priests and chantresses of Amun, all of whom date to the 21st Dynasty (1069 BC–945 BC). A plentiful quantity of funerary goods was discovered stored with the priests' mummies, but unfortunately the quick of clearing the cache resulted in that no records were kept for many of these objects. The discovered collection from Bab El-Gasus is one of the largest, famous and most important in the Cairo Egyptian Museum, crucial for understanding the history, culture and society of Egypt in the 21st Dynasty. Due to the combination of poor documentation, limited publication, and out of date display, along with displacement into storage because of the steady increase in the numbers of objects in the Cairo Egyptian Museum, have led to the neglect of this discovery by scholars and lack of appreciation and due respect amongst museum-goers and the public. Included in the recovered materials are 'mummy cloths', twenty-four of which are now in the Cairo Egyptian Museum. They are behind glass, fixing on a wood board, covered with cloth and labelled from A to Z. They hold the Serial Register numbers 14376 to 14399 (Abdul Allah, 1988). The discovered textiles provide significant information about the funerary functions of linen, as well as technical aspects of Pharaonic funerary textiles (Hallmann, 2015). One of them is the study object which is the mummy cloth of Khonsuemrenep (a priest and scribe of Amun). In accordance with the accounts of Winlock and Daressy, each mummy was wrapped within a protective sheet of linen, wider and longer than the body. The ends were tied or tucked under the head and feet. The edges of this sheet were then sewed on the back. Over this protective sheet was a double band of linen, crossing in the middle. After removing the bands and the protective sheet, there was another piece of linen, coarse and thick, this kind of a mummy cloth is commonly ornamented with black or red ink with a painted life-size figure of Osiris, wearing the; *tf*-crown and a false beard, arms crossed and holding the flail and *hqi*-sceptre and spells or chapters from the book of the dead alongside the name of the deceased (Abdul Allah, 1988). The cloth was spread over the bandages of the mummy and then fastened in place by ties woven for the purpose. Described by Winlock, as 'Osiris sheets', (Winlock, 1926) and by Daressy (Daressy, 1902) as 'toile', 'linge', or 'suaire' they are termed also by Aly Abdulla (Abdul Allah, 1988) as Osiris-cloths, because they do not depict any deity except Osiris. An example of which was also found over the mummy of Hatnefer (Cairo JE66218) (Nicholson, et al., 2000).

3. MATERIALS AND METHODS

3.1. Description of The Mummy Cloth Object

The study object is the mummy cloth of Khonsuemrenep (a priest and scribe of Amun) and it held serial number (SR 14396) (Fig.1, a). It is a rectangular piece of cloth, with drawing of Osiris figure on a small platform, and in front of him a standing figure of the deceased, in a short kilt, with shaven head, one arm raised in adoration, the other held at the side. Both figures were drawn in black ink, and there is eight short vertical lines of hieroglyphic text in black, above their heads (Fig.1, b), reading: Htp-di-nsw Wsir nb nHH xnty imntt wnn-nfr HQA anxw di.f Htpw DfAw Wsir wab n Imn-Ra nsw-nTrw sS sHn n pr In-Hrt Hry sS n pr sHn pr Wsir nb AbDw xnsw-(m)-rnp mAa xrw wAst : ''*A boon which the king gives to Osiris, lord of eternity, Khenty-Amenty, Onnophris, ruler of the living ones. May he give offerings and provisions (to) the Osiris, the priest of Amon-Re, King of gods, the scribe of commands of the estate of Osiris, the chief scribe of the department of orders of the estate of Osiris Khonsemrenep, justified, Thebes*"(Abdul Allah, 1988). The mummy cloth measures just over 181 by 85 centimeters' in size, which is considered one of the largest known painted mummy cloths from its period. It has fringes at the bottom; the other borders have a selvedge. It has three sets cords on either side at the top, middle and bottom. The use of these cords is to fasten the cloth to the mummy. The textile object was stored in the third floor storage of the Cairo Egyptian Museum within a glass showcase by folding the side borders and the bottom part behind the cloth and fixing on a wooden board with metal pins and nails (Fig.1,a).

A

B

Figure 1, A) The studied mummy cloth object before restoration, B) the vertical lines of hieroglyphs above the images of Osiris.

3.2. Methods of examination

Before any attempt was made to assess the conservation requirements of the textile object a thorough examination of the materials used in their construction was carried out by multi-analytical approach to identify the materials and methods used in the manufacturing of the mummy cloth, to assess its condition, and the state and the extent of deterioration of the fibres. In this study the scientific examination was carried out by:

Dino-Lite portable digital microscope: USP digital microscope, 2.0 interface, type RK-10A with a maximum magnification of 500x.

Ultraviolet-Visible (UV-VIS) microscope: The images were acquired by NIKON ECLIPSE E600) with fibres Optic Visible source (Shott KL 1500) and a high- pressure mercury lamp as UV source (UV-2A-EX330-380- DM400- BA 420). The camera used for capturing the images is NIKON DS- FI1C, NIKON DS-U3 Digital Sight. The software used is Nikon ACT-V2.6.

Scanning Electron Microscopy with energy dispersive X-ray spectrometer (SEM-EDX): The samples were examined in a Jeol JSM 5600 system configured with an EDX detector, operating at 20-kV accelerating voltage and 20-mm working distance. The surface morphology of fibre samples was measured on small pieces coated with a thin film of gold for 90 seconds, using POLARON SC 7620 SPUTTER COATER to increase their conductivity and to avoid charging effects [16]. The EDX data were assembled for analysis using the Link ISIS system (Oxford Instruments, UK).

Fourier-transform Infrared (FTIR): FTIR Spectra were obtained using a Perkin–Elmer Spectrum GX FTIR system. The samples prepared as KBr pellets. The collected spectra have been expressed by absorbance units in the 4000 to 370 cm−1 range, at a resolution of 4 cm^{-1} and baseline has been corrected. The IR results were conducted over the normalized spectra and compared with standard known spectra.

Portable XRF Spectrometry (PXRF): PXRF was carried out at Cairo Egyptian Museum, using the portable ELIO XGLab srl (https://www.xglab.it/compact-portable-xrf-spectrometer-elio.shtml). The PXRF head was mounted on a stable tripod equipped with a lateral sidearm (60 cm long). For the measurement conditions were used: working distance ~1.4 cm, tube voltage = 40 kV, tube anode current = 20 µA, acquisition time = 40, 0 s, on a 50 kV-4W X-ray tube generator.

X-Ray powder Diffraction (XRD): XRD patterns were recorded on a Bruker AXS D8 Advance diffractometer in Bragg–Brentano geometry equipped with a Cu sealed-tube radiation source (λ = 1.54178 Å) and a secondary beam graphite monochromator.


A

B



C


D

E

F

Figure 2 (A, B, C, D, F) Various aspects of deterioration of the mummy cloth object such as dust, dirt, tears, missing parts, stains, creases, wrinkles and improper storage by metal nails.

4. RESULTS AND DISCUSSION

4.1. Condition assessment

Visual examination by USB digital Dino-Lite and UV-VIS microscope, it was assessed that the mummy cloth is in a very poor physical condition, the fibres were degraded (stiff, fragile and brittle) and the black pigment was very friable as a result of drying out. Also, accumulations of dust, dirt was found on and between the fibres (Fig.2 & Fig3.B, C) and some old spider threads had gathered between the mummy cloth and the support cloth at the edges. This damage might be a consequence of inappropriate storage in too dry conditions and may also have occurred before excavation or may be a consequence of soiling. There were big holes and tears and many areas of loss, particularly in the area of the inscriptions maybe because of the black ink, where the paint has been heavily applied, leading to the surface of the cloth deteriorated (Fig.2). The fringed ends were broken down at the minimal movement; the twisted cords are loose, brittle and missed much fibre. There was evidence of insect attack, perhaps woodworm. Folding of the textile irregularly and not in the proper way since displayed results in the presence of lots of creases and wrinkles in different areas of the object (Fig.2). Dark brown stains were observed on some parts of the linen piece, these stains might be caused due to using of resins during the embalming process.

4.2. Technical Analysis

The standard procedures for textile analysis (i.e. thread count, twist direction, thread density and weaving structure, Walton & Eastwood, 1988), were used to identify the mummy cloth characteristics, in addition to the diagnostic features of the fabric and decoration. The dimensions of the object are 181 x 85 cm in size, which considers one of the largest known painted mummy cloths from its period. The weave pattern of a base fabric: tabby weave 1/1, with S-twisted threads, (Fig.3.B, C) count of warp threads: 12/cm, count of weft threads: 8/cm, warp: linen, weft: linen. The thread count used for the base fabric is 15 Nm (number metric, counts per thread), the diameter of warp threads (0.3mm), the diameter of weft threads (0.5mm). There are two borders of the fabric: upper and lower. The weave structure of these borders was woven by about 2 threads have been inserted as weft to obtain the ribbed structure (Fig. 3.G). The piece has selvedge in both sides which reveal that it was made particularly for this purpose (Fig. 3.H). It was noted that the piece is ended with warp fringes in the bottom edge about 13 cm length made from the warp threads that are braided together (Fig.3.I). Furthermore, it was observed that there are 3 tight woven strips (Fig3.J, K) in the bottom of one side of the textile object, count of warp threads: 48/cm, count of weft threads: 22/cm. The presence of many knots spread on the fabrics surfaces. This may be attributed to that the weaver made these knots to join the warp threads or the weft threads together which indicated that not all of the threads were of the same length and width of the used loom (Fig3.L).

Optical and UV-VIS microscope illustrate that the painting process of the mummy cloth was done directly by utilizing a black pigment and brush without a ground layer (Fig.3. D, E, F). This technique is the most commonly used in painting textiles in ancient Egypt (Taro, 1993). The central figure was found to have a thicker, more uneven application of pigment.

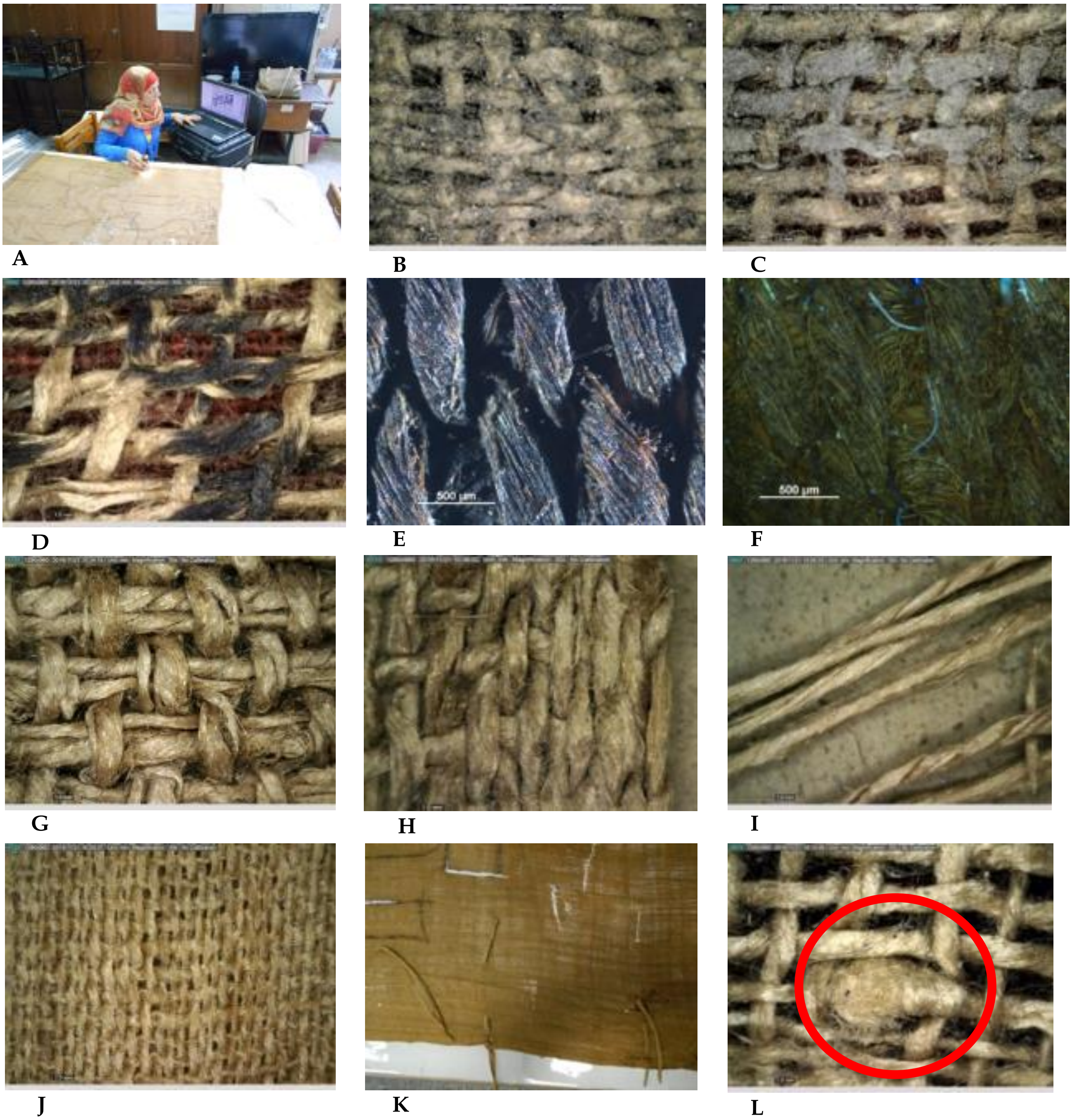


Figure 3.A, During investigation with USP digital microscope. (B, C, D): USP microscope images show weave structure of the body of the mummy cloth and accumulations of dust, dirt on and between the fibers. (E, F): UV-VIS images illustrate the painting technique of the object, (G, H): weave structure of the borders and the selvedges, (I): fringes in the bottom and twist direction of the fiber. (J, K L): the knots on the textile surface.

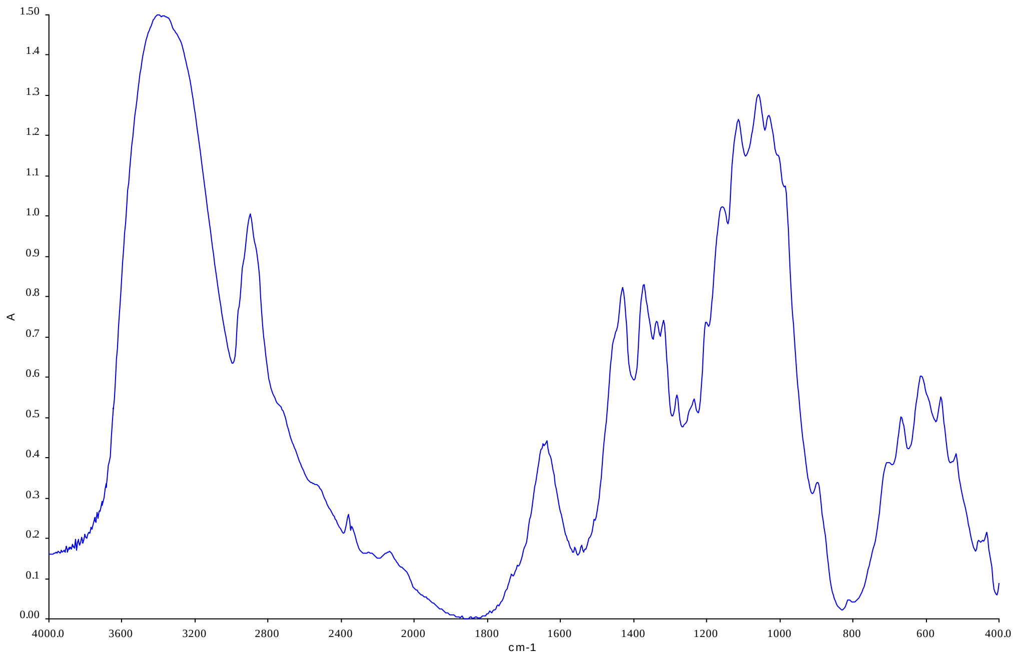
4.3. Fourier Transform Infrared Spectroscopy (FT-IR)

Characteristic infrared bands of standard and ancient samples are shown in Table.1 and in Fig (4.A, B).

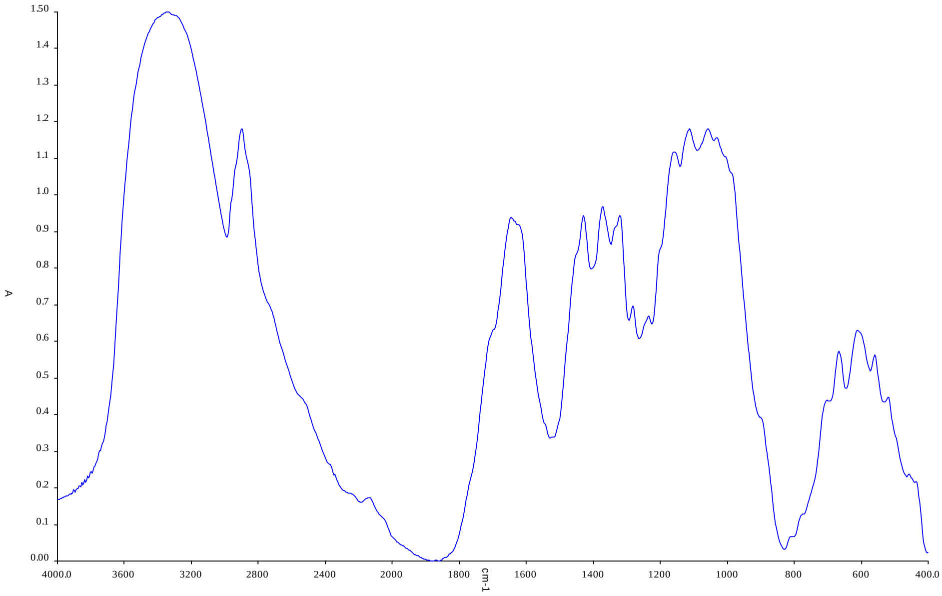
It is shown that the spectral patterns are very similar and differ only in the diffractograms intensity but not in the shape. The most intense bands in Fig. 4 (A, B) are more similar in the wavenumbers as follows: The bands at 3424, 3346 cm^{-1} respectively, pointed to the presence of hydroxyl groups and are assigned to the stretching ν(OH) vibrations. The bands at 2901, 2900 cm-1 are attributed to stretching vibrations of methyl and ethyl groups $\nu(CH3)$ and $\nu(CH2)$ (cellulose compounds), also assigned to gum arabic ν(CH). The bands at 1638, 1646 cm^{-1} are assigned to vibrations of ν(C=C) (lignin compounds), ν(CO) and δ(OH), bonds (resulted from aldehydic or carbonyl, or carboxyl groups)(Katja, et al., 2011; Acquaviva, et al., 2010). The bands at 1432, 1430 cm^{-1} are attributed to [C=C conjugated double bond stretching], assigned to Arabic gum. The bands at 1372, 1373 cm^{-1} are assigned to bending vibrations of ethyl and methyl groups $\nu(CH2)$ and $\nu(CH3)$ (cellulose compounds). also attributed to[C-H bending] assigned to Arabic gum (Ganitis, et al., 2004). The bands at 1230 , 1283 and 1235, 1282cm^{-1} are assigned to carbon (Bellamy, 1975). The bands at 1115, 1113, 1059, 1060 cm^{-1} are assigned to C–O bridge stretching and C–O–C pyranose ring skeletal vibration (β-glycoside linkages, cellulose compounds, also assigned to Arabic gum. The bands at 668, 615, 668, 611$cm^{-1}$are attributed to [Aromatic CH bending] (Ajò, et al., 2004). Thus, the FTIR results illustrate that the fibre of the mummy's cloth object is the linen fibre coloured with carbon-charcoal, the results also indicate that the medium used for ink preparation is Arabic gum. Moreover, FTIR inicates that the ancient linen fibres are very damaged indicated by the presence of functional groups typical of deteriorated cellulose. The linen sample was clearly degraded as the ratio of the peaks for carbonyl and carboxyl functional groups is higher than that of new linen fibre without (Abdel-Kareem, et al., 2008). This carbonyl functional group could be resulted from either aldehyde group at 1600 cm^{-1} or carboxyl group at 1720 cm^{-1} resulting of the oxidation of the hydroxyl group, reflecting the disintegration of glycosidic linkages in the cellulose fibres (Timar-Balazy, et al., 1998 & Abdel-Kareem, 2005). Furthermore, the degradation of the ancient fibres reduced the strong IR absorption bands present in the spectrums as a result of natural ageing (May, 2006).

Table.1. Characteristic FTIR bands in cm^{-1} of standard coloured linen fiber with black charcoal and ancient coloured black fiber of the mummy cloth.

Sample	Wave numbers (cm^{-1})
Standard linen colored by black charcoal	3424, 2901, 1638, 1432, 1372, 1230 , 1283,1156, 1115, 1059,668, 615, 560
black coloured ancient fibres of the mummy's cloth	3346, 2900, 1646, 1430, 1373,1321, 1282, 1235,1159, 1113, 1059, 668, 611, 562



A

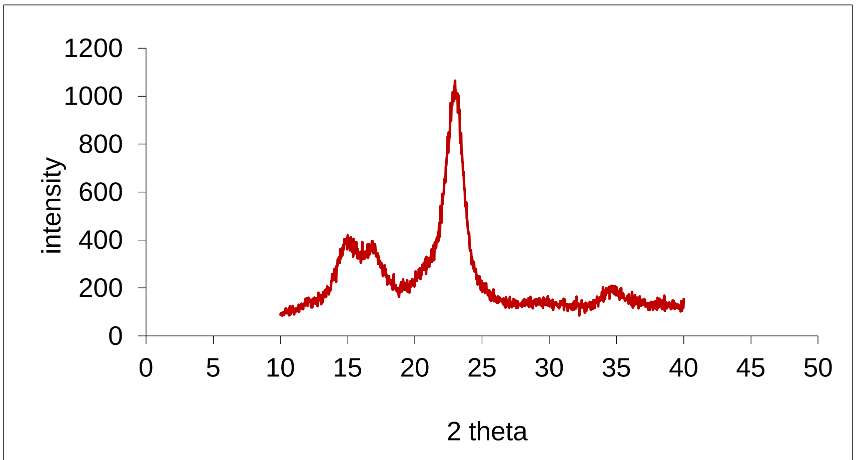


B

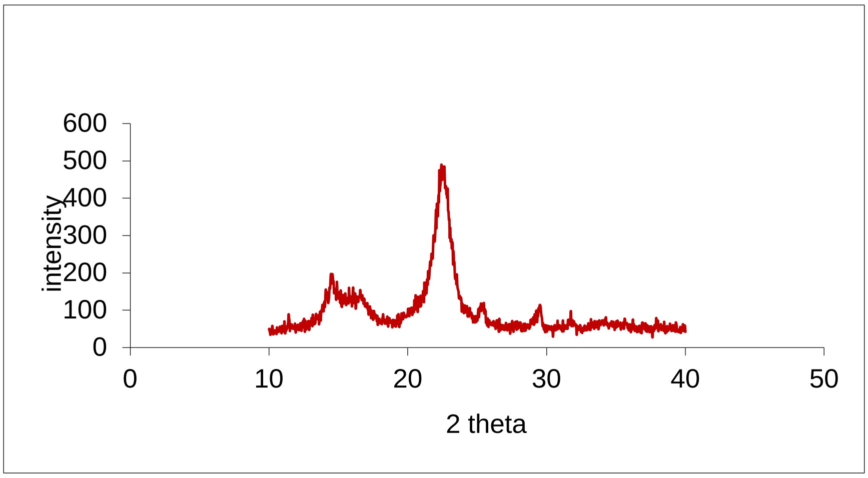
Figure 4.A, FTIR spectra of standard colored linen fiber with carbon black and Arabic gum; B, the IR spectra of the colored mummy's cloth fiber.

4.4. X- Ray Diffraction

The data of X-ray diffraction spectra for the ancient and standard new linen fibres are presented in Fig.5 (A&B). It is clear from the results that the x-ray diffractograms of standard and the ancient linen fibres are very similar and differ only in the intensity counts but not in the shape. Also, it can be shown that the x-ray diffractogram exhibits three principal planes of reflection (101), (10¯1), (002) with peaks at 2θ= 14.9°, 16.6o and 22.8° respectively, which attributed to cellulose I of linen fibre (AL-Gaoudy, et al., 2011). This indicates that the ancient fibres are made of linen fibres; this result is compatible with FTIR result. The lower intensity of (101) and (10^{-1}) peaks is ascribed to the relative orientation of the crystals in the fibres (Oh, et al., 2005). On the other hand, the (002) reflection is the most intense peak and ascribed to the crystallographic planes of the charged glycosidic moieties (Eichhorn, et al., 2003). The results have shown reducing in the crystalline properties of an ancient linen fibre comparing with the standard new linen, disclosing an increase in the amorphous areas due to natural ageing. The crystallinity index was found to be around 94% for the standard new linen and 83% for an ancient sample of the mummy's cloth. Generally, the decreasing of crystalline properties of the mummy cloth sample indicates the formation of amorphous material (Geaa et al., 2011).



A



B

Figure 5. A) X-ray diffractograms of standard linen fiber. B) X-ray diffractograms of the mummy's cloth fibers.

4.5. Portable ED XRF spectrometer (pXRF)

The essential advantages of PXRF techniques are their rapidly, enabling multi-component analysis, absolutely non-destructive and giving simple spectra, precision, and reproducibility. Implementation of this technique to the analysis of artifacts have been related to the identification and determination of major, minor, and trace elements composing inorganic materials such as surface coatings, pigments, stone, glass, ceramics, metal, and accretion of incidental materials on the surface, etc. (Streli, et al., 1999). In this study, PXRF was carried out to identify the unknown elemental compositions of the textile object. The PXRF result shows that the Elemental compositions seem to be dust and dirt. The presence of Cl and Ca elements in PXRF analysis is indicative of the existence of calcium chloride ($CaCl_2$) as shown in Table 2. This may perhaps be related to the burial soil that surrounded the mummy cloth.

Table.2, Elemental concentrations (in % w/w) determined through PXRF analysis in the ancient sample

Element	Concentration	Error
Ca	65,45%	±1,18%
Cl	18,22%	±4,72%
Fe	9,5%	±1,22%
K	4,04%	±5,26%
Ti	1,69%	±5,59%
Zn	0,79%	±3,14%
Cu	0,19%	±7,07%
Sr	0,1%	±6,23%
Nb	0,02%	±7,35%

4.6. Scanning Electron Microscope (SEM-EDS)

S.E.M images of the examined ancient fibres, collected from the mummy cloth, are illustrated in Fig.6. These photos showed clear views of the morphology of the fibres of the mummy cloth object. SEM images show that the warp and weft fibres of samples have a cylindrical shape, smooth surfaces, and reveal nodular thickening across their length, all of which are features of cellulosic bast fibres [linen]. Observation of the surface morphology of the fibres disclosed a high degree of degradation and damage. The fibres break down into their structural units, fibrils or macro fibrils. This occurs as a result of extensive flexing and is due to heavy stress (tension) of the fibre probably during wear or re-use of the textile in the embalming, during the time they were deposited within the burial and after they were discovered. Linen fibres appear harshly damaged as tearing, breaking, and thus the other fibre with broken ends (Brush end) appearance. This degradation has occurred as a result of fracture of the glycosidic bond between the units of the cellulose fibres, and from the hydroxyl groups which may be initially formed during oxidation, and hence cause scission to the molecular chains of the linen cellulose polymer (Timar-Balazy, et al., 1998, 12-13). The results of SEM photographs and EDX analysis show that there's various contamination, whereas a lot of soil particles were often found everywhere along and between the fibres, this evidence demonstrates that the fabric appears very dirty. All these degradation aspects presumably indicate that the fibres had deteriorated over the long time of ageing and improper storage at Cairo Museum, caused by oxidation and hydrolysis which can lead to the formation of fragile fibres.

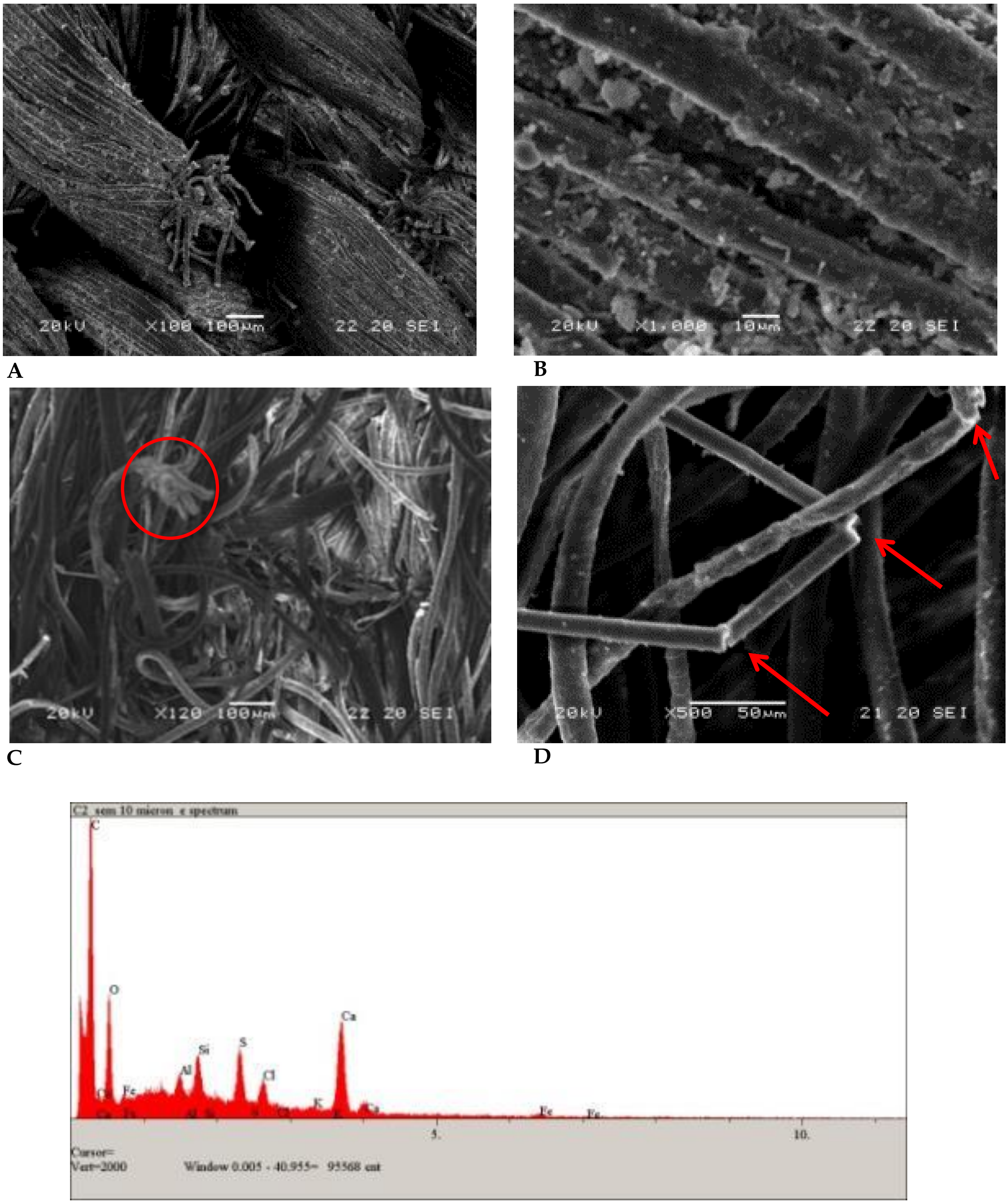


Figure 6 (A, B, C, D) SEM microphotographs shows deterioration aspect of mummy's cloth fibers such as (dirt contamination, tearing, breaking and fibres with broken end. E), EDX result shows contamination as dust, dirt on the object surface.

5. CONSERVATION STRATEGY OF THE MUMMY CLOTH OBJECT

Treatment processes carried out to the object reflects conservation strategy of techniques, materials and approaches that currently in use at the Cairo Egyptian museum in the stabilization of fragile ancient Egyptian textiles. This includes the use of efficient low-tech solutions that require little equipment and conservation materials. The techniques are easily applicable, taught to other young conservators at Egyptian museum and the most importantly, the treatments remain easily reversible. After all treatments, the mummy cloth has retained his integrity, whereas becoming more stable, cleaner and more coherent.

5.1. Cleaning

The mummy cloth object was cleaned mechanically by using different types of fine brushes and vacuum cleaner to remove free dust and dirt that not stuck to textile fibres (Ahmed, et al., 2011, Amin, 2018). It was noticed that mechanical cleaning was fulfilled the objective and most of the dirt was removed (Fig.7, B). Thereby, there is no need to do any other cleaning process.

5.2. Testing Stability and consolidating the Black Ink

The Stability of textile dyes or pigments is always implemented foremost to determine the response of the dyes to the cleaning and to identify the most appropriate treatment procedure (Amin, 2018). The textile object was tested before humidification, by putting a piece of cotton around a wooden stick dipped in water and placing it in contact with the black coloured parts. It was found that the black ink was not stable and drains upon contact with the moistening solution. Hence, it was necessary to fix the black ink before the humidification (Ahmed, et al., 2011). The solution of low concentrations (2.5%Paraloid B72® in xylene®) is found to be matt and flexible. The use of a comparatively slow-drying solvent (xylene) secured that there was adequate penetration (Hillyer, 1984). Paraloid B72 (ethyl methacrylate methyl acrylate copolymer) was applied with a fine paintbrush from the middle of the painted parts to the outer, in order to not spread and absorb the solution to the other parts of the object that may cause dark marks on it (Shashoua, et al., 1999). The colours lost their somewhat dusty appearance and became rather brighter. The powdered areas became quite firm and the object as a whole maintained its flexibility.

A

B

Figure 7.A) The mummy cloth on a work table, before the treatment. B) During mechanical cleaning.

5.3. Acidity (PH) measurement

The normal pH of linen fibres is in the alkalic range. High acidity leads to increase the disintegration of cellulosic materials through an irreversible process, resulting in brittleness and loss of physical properties (Kourkoumelis, et al., 2012). The measurement of the PH of the linen fiber surface was done using both pH-indicator strips (non-bleeding, Merck KGaA, Germany) and PH meter (Fig.8, A). It was found that the linen was acid and had a PH in the range of (4–5). This acidity may be caused by the migration of acids from the old wood panel and the lining fabric that was used for storing the mummy cloth for long periods.

5.4. Humidification Treatment

Humidification treatment allows the slow introduction of water into the textile fibre in the form of small groups of molecules, and in this way, it minimizes the risk of physical degradation which can be resulted from the liquid form of water when reshaping the linen fibres. Humidification was carried out as the most proper method to relax creasing and distortion in the linen fibres, in order to keep the fibre from further breakage and to facilitate the mounting and display of the mummy cloth. In this study, the Humidification was done by using Gore-Tex® sheet and poultices (Fig.8, B) which could appear to be particularly appropriate for large textile objects that can't be put within the humidification chamber (Ishii, 2013). Firstly, the mummy cloth was put between 2 sheets of Gore-tex. Then, application of a poultice of acid-free blotting paper with deionised water locally on the textile allows the moisture to migrate slowly and vertically via the poultice to the textile fibres, cover the entire set with polyethylene sheet® to reduce vaporizing of the water swiftly, then, leave it for 10-15 minutes to allow individual water molecules to pass and relax the fibers through the porous of Gore-tex sheet. eventually, remove the poultice from the textile object, and that will relax the fibres adequately to flatten the wrinkles with hands and reshape the textile parts to its original shape (Fig.8, C) by placing glass weights (Ahmed, et al., 2011).

A

B

C

Figure 8.A) during measuring PH of the mummy cloth. B) Humidification using Gore-Tex. sheet and poultices. C, after Humidification and reshaping the mummy cloth to its original shape

5.5. Reinforcement and displaying

The mummy cloth was mounted flat on a board and held in place with glazing sheet-termed as-pressure mounts. Pressure mounting was chosen because it provides a powerful choice for both conservation and display for very fragile textiles or fragments. Moreover, in this method, the changes in preference or interpretation can be done quite simply, depending on the object's state of preservation, by lifting the glazing layer and removing textile and disguise underlayers (Bayer, 2016). In this study case, stitching techniques was eliminated due to the likelihood of the needle and thread causing damage to the degraded linen and a painted surface. The probability of overlaying the mummy cloth with net and only stitching around the edges was considered improper due to the importance of the text and for aesthetic point of view. Consolidation with adhesives are to a lesser degree practiced today because of the problems reported from past treatments, such as loss of fabric structure and loss of information, non-reversibility of aged adhesives (Ishii, 2013). The Reinforcement of the textile object by pressure mounting was achieved as follows:

1. Prepare a base of a wooden board, according to Abdel-Kareem and Schofer (Abdel-kareem, et al., 2001) which is covered first with padding materials (free-acid carton and non-woven cotton fabric®), and finally with a linen fabric.
2. Prepare a dyed crepeline® support with natural dye, appropriate with the colour of the studied textile object,
3. The mummy cloth was placed face down. The previously dyed silk support was placed on the back of the mummy cloth, making sure that the warp is correctly aligned and all separated and tearing parts in its right place. It was fastened firmly in place and flattened it out as flat as possible neither using any adhesives nor putting it under pressure.
4. Finally, the mummy cloth was laid flattened directly onto that prepared cloth-covered padded board.

A filtered U.V. and antistatic acrylic sheet (Plexiglas) ® was chosen because it is less likely to break and light in weight (Bayer, 2016). It was placed on top holds the mummy cloth in place when the board is lifted from horizontal to vertical, and whole layers are held together tightly between the padded base and the acrylic sheet (Fig.9,B).

Figure 9. A) The studied Osiris cloth before restoration. B) The Osiris cloth object after restoration.

6. CONCLUSION

Ancient Egyptians were proficient for production of high quality linen textiles with various types, characteristics and usages in their life, although on the other hand they used linens also for burial shrouds and mummification purposes.

The mummy cloth of Khonsuemrenep (a priest and scribe of Amun) dating back to 21th dynasty, was termed as Osiris cloth because it does not depict any deity except Osiris. It was found in Bab El-Gasus tomb, which is one of the important excavations found in Deir El-bahari at Thebes.

Scientific examination results illustrated various remarkable findings which disclosed some of the distinctive characteristics and versatility of ancient Egyptian textiles, offering new insights into the mummy cloth production techniques used at 21st Dynasty. Moreover, the results illustrated that the mummy cloth object is in a very poor physical and chemical condition, the painting process was done directly by utilizing black charcoal, and Arabic gum as a medium and brush without a gesso layer.

It was observed that the treatment target and purpose both have been successfully achieved. The simple treatment transformed the mummy cloth object into an object whose original design was once again explained. The mummy cloth demonstrated an optimal candidate for the method of minimum treatment because it responded effectively to mechanical cleaning and humidification. The treatment processes carried out to the textile object reflects the conservation strategy of techniques, materials, and approaches that are currently in use at the Cairo Egyptian museum in the stabilization of fragile ancient Egyptian textiles.

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Appendix I

Materials and suppliers

Name	suppliers/manufacturer
Paraloid B72(*ethyl methacrylate copolymer)*	Rohm & Haas (UK) Ltd, Lennig House, 2 Mansons Avenue, Croydon CR9 3NB, UK
xylene(dimethyl benzene)	Sigma-Aldrich Company Ltd.,The Old Brickyard, New Rd, Gillingham, Dorset, SP8 4XT
non-woven cotton fabric	Preservation Equipment Ltd Vinces Road, Diss, Norfolk IP22 4HQ, UK.
Silk crepeline	C.T.S.Via G Fantoli n. 26 00149 Roma (RM)
linen	Eglan company, Alexandria , Egypt
polyethylene sheet	TALAS ,330 Morgan Ave.Brooklyn,
acrylic sheet(Plexiglas) polymethel methacrylate	Sunplas Co., Ltd. No.159 Zhujiang Middle Road, New Hi - Tech District, Jiangsu, China,

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