# حولية كليةالآداب

## سنوية محكمة علمية

تصدرها كلية الآداب- جامعة بني سويف

**عدد خاص** **يناير٢٠١٨**

**الترقيم الدولي الموحد للدوريات**
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**مركز جامعة بني سويف للطباعة والنشر**

# هيئة التحرير

# الهيئة الاستشارية

## الهيئة الاستشارية المحلية للحولية([1])

| | |
|---|---|
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| أ.د.محمد عبد الوهاب خلاف | قسم التاريخ |

([1]) تم ترتيب الأسماء استناداً لتصنيف ديوى للمعرفة البشرية ، ثم هجائيًا بالأسماء

## الهيئة الاستشارية الخارجية للحولية(١)

| | |
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(١) تم ترتيب الأسماء استناداً لتصنيف ديوى للمعرفة البشرية ، ثم هجائياً بالأسماء

# عن الحولية

حولية كلية الآداب جامعة بني سويف حولية علمية محكمة تصدر سنوية بهدف نشر الإنتاج العلمي في مجالات العلوم الاجتماعية والسلوكية" السياسة، الاقتصاد، الاحصاء، القانون، الإدارة العامة والعلوم العسكرية، الخدمة الاجتماعية والجمعيات الأهلية، التعليم، النقل والاتصالات والتجارة، العادات والتقاليد وآداب السلوك والفلكلور" واللغات والآداب والإنسانيات، وتحقيقا لهذا الغرض يُنشر في الحولية الأبحاث والدراسات العلمية.

وتتضمن الحولية بجانب البحوث التي يتقرر نشرها، عروضًا للكتب حديثة الصدور في مجالات العلوم الاجتماعية والإنسانية، كما تتضمن ملخصات وعروضًا لرسائل الماجستير والدكتوراه المجازة من الكلية أو الكليات المناظرة، وتقارير اللقاءات العلمية (المؤتمرات والندوات والحلقات العلمية).

وتراعي هيئة تحرير الحولية إتباع قواعد التحكيم العلمي التي يجرى العمل على أساسها في المجالات العلمية وذلك لتحديد صلاحية ما يرد إليها من مقالات وبحوث. هذا وينشر كل بحث بعد موافقة كتابية على نشر البحث من محكمين على الأقل.

## قواعد النشر بالحولية

### ❖ أولا: شروط النشر

١- ترحب الحولية بنشر البحوث والدراسات العلمية التي تتسم بالأصالة والجدة، بإحدى اللغتين العربية أو الإنجليزية، شريطة أن يرفق بالأبحاث والدراسات العلمية مستخلصان، أحدهما بالعربية، والآخر بالإنجليزية، كما تنشر التقرير السنوي عن انجازات الكلية، وكذا لمسة وفاء (حيث يتم البدء بنشر رسائل الماجستير والدكتوراة لأعضاء هيئة التدريس الذين توفاهم الله أثناء إعدادهم لرسائلهم وذلك تكريمًا لهم وحفاظًا على حقوقهم العلمية والأدبية.

٢- كما ترحب الحولية بنشر الترجمات، وملخصات الرسائل الجامعية المجازة من الكلية أو الكليات المناظرة، وتقارير المؤتمرات والندوات والحلقات الدراسية، وعروض الكتب حديثة الصدور في مجالات العلوم الاجتماعية والإنسانية .

٣- لا يتم نشر الدراسات التي سبق نشرها بأي صورة من صور النشر، أو قدمت للنشر لجهة أخرى، ويُعدّ إرساله إلى الحولية تعهدًا بذلك، وفي حال قبوله للنشر في الحولية لا يسمح للباحث بنشره في مكان آخر.

٤- يلتزم الباحث بعدم تقديم الدراسة المقدمة للنشر إلي أي مجلة أخري، وذلك حتي يتم إعلامه بنتيجة التحكيم.

٥- يتحمل الباحث تكاليف تحكيم البحث سواء قُبل للنشر أم لم يُقبل.

٦- لن ينظر إلى الأبحاث التي لا تتفق وشروط وقواعد النشر بالحولية ، أو ترد ناقصة لملخص البحث في أي من اللغتين.

٧- لا ترد أصول الأعمال المقدمة للحولية سواء قُبلت للنشر أم لم تُقبل.

## ❖ ثانيا: إجراءات النشر

١- يقدم الباحث نسختين ورقيتين من البحث على ورق (A4) بالإضافة إلى نسخة إلكترونية على CD أو عبر البريد الإلكتروني.

٢- يلتزم الباحث بتقديم سيرة ذاتية مختصرة تتضمن: الاسم كاملا، والدرجة العلمية، وجهة العمل، والعنوان البريدي، والبريد الإلكتروني، وأرقام الهواتف (الأرضي والمحمول) والفاكس من أجل سهولة الاتصال وسرعته.

٣- تقوم هيئة التحرير بالقراءة الأولية للبحوث العلمية المقدمة للنشر بالحولية للتأكد من توافر مقومات البحث العلمي، وترسل بعد ذلك إلى المحكمين، مع مراعاة ما يلي:

- تختار هيئة التحرير شخصًا من جهة علمية مختلفة يعهد إليه بمهمة التحكيم، على أن يكون متخصص في مجال البحث، ويفضل أن يكون بدرجة أستاذ أو أستاذ مساعد.
- يرسل العمل العلمي إلى المحكمين بصفة سرية بدون ذكر اسم الباحث أو ما يدل على شخصيته، ويرفق مع العمل العلمي المراد تحكيمه استمارة تقويم تضم قائمة بالمعايير التي على ضوئها يتم تقويم العمل العلمي.
- يتولى أعضاء هيئة التحرير متابعة إجراءات التعديل والتحقق من استيفاء التعديلات المطلوبة قبل نشر العمل العلمي.

- يتم إبلاغ جميع الباحثين بقرار صلاحية بحوثهم للنشر من عدمه.
- ينشر العمل العلمي إذا اجتاز التحكيم وفق الضوابط العلمية المتعارف عليها واستوفى قواعد وشروط النشر بالحولية ، ويعتذر عن نشره في حالة عدم تحقق ذلك.
- يكتفي بالإجازة من قبل اثنين من أعضاء هيئة التحرير لنشر مراجعات الكتب والرسائل الجامعية وتقارير اللقاءات العلمية.

## ❖ ثالثا: سياسات النشر

١- تعطى الأولوية في النشر للبحوث والتقارير حسب الأسبقية الزمنية للورود إلى هيئة تحرير الحولية ، وذلك بعد إجازتها من قبل المحكمين، ووفقا للاعتبارات العلمية والفنية التي تراها هيئة التحرير.

٢- يتم ترتيب الأبحاث داخل العدد موضوعيًا وفق خطة تصنيف ديوي العشري العالمية المستخدمة في تصنيف المعرفة في المكتبات، وفي الموضوع الواحد يراعى الترتيب وفق الدرجة العلمية لصاحب العمل، ثم هجائيًا.

٣- يراعى الترتيب التالي في أجزاء البحث: صفحة العنوان، المستخلص باللغة العربية، المستخلص باللغة الإنجليزية، الكلمات الدالة، المقدمة المنهجية، النتائج ومناقشتها، المراجع، الأشكال والجداول والملاحق.

- يسجل على صفحة العنوان: عنوان البحث في منتصف الصفحة، واسم الباحث / الباحثين متبوعًا باسم المؤسسة التي يعمل / يعملون بها، والبريد الإلكتروني الخاص به / بهم.

- يراعى أن يكون المستخلص في حدود ١٥٠ كلمة، وخال من الاختصارات والمراجع، ويشير بوضوح إلى أهداف البحث ومنهجيته وأهم نتائجه.
- يقصد بالكلمات الدالة: المصطلحات الرئيسة التي وردت في متن البحث أو المباحث الفرعية التي تم تناولها.
- يراعى في المقدمة أن تقدم خلفية كافية عن الموضوع وأن يوضح بها المنهج المتبع وأدوات جمع البيانات وإجراءات الدراسة والتحليلات الإحصائية المستخدمة، إن وجدت، والدراسات السابقة، والمثيلة.
- بعد المقدمة المنهجية يتم عرض النتائج التي توصل إليها الباحث، يلي ذلك مناقشة هذه النتائج ومناقشة صحة فرضيات الدراسة ومدى ارتباط النتائج بالأعمال المنشورة التي تناولت نفس الموضوع.
- يراعى عدم وضع الجداول الكبيرة والأشكال التوضيحية والخرائط الكبيرة في متن البحث بل توضع في نهايته حتى يتمكن المراجعون من التحكم في حجمها وفق حجم صفحة الحولية ، أما الجداول والأشكال التي توضع في متن البحث فيجب أن يكون كل منها في صفحة مستقلة على أن يوضع رقم الجدول وعنوانه أعلاه، ورقم الشكل وعنوانه أدناه.
- تسجل المراجع على النحو التالي:

<u>في حالة الكتب:</u>

اسم المؤلف (سنة النشر). عنوان الكتاب.- رقم الطبعة.- مكان النشر، اسم الناشر.

**في حالة مقالات الدوريات:**

**اسم المؤلف (سنة النشر). عنوان المقال.- عنوان الدورية.- رقم المجلد (رقم العدد)، الصفحات التي يشغلها المقال.**

**في حالة المصدر الالكتروني على الويب:**

**اسم المؤلف (تاريخ الإتاحة على الموقع). عنوان المصدر الإلكتروني. متاح على الرابط: <يوضع الرابط> تاريخ الاطلاع.**

## ❖ رابعا: حقوق النشر

**١- يُمنح كل باحث إفادة بقبول بحثه للنشر بعد إتمام كافة التصويبات والتعديلات المطلوبة بعد التحكيم.**

**٢- يُمنح كل باحث عشر مستلات من بحثه المنشور، بالإضافة إلى نسخة واحدة من الحولية**

## ❖ خامسا: رسوم النشر

**بعد قبول البحث أو الدراسة للنشر يسهم الباحث في تكاليف طباعة بحثه ونشره على النحو التالي:**

| م | الجهة التابع لها الباحث | رسم تحكيم البحث | تكلفة الصفحة | |
|---|---|---|---|---|
| | | | العدد الأساسى | العدد الخاص |
| ١ | كلية الآداب ببني سويف | ٢٠٠ : ٢٥٠جنيهًا مصريًا | ١٢ جنيهات مصرية | ٢٤جنيهات مصرية |
| ٢ | أعضاء هيئة التدريس بالجامعات المصرية | ٢٠٠ : ٢٥٠جنيهًا مصريًا | ١٥ جنيهات مصرية | ٣٠ جنيهات مصرية |
| ٣ | أعضاء هيئة التدريس المعارون للخارج من كافة الجامعات المصرية | ٢٠٠ : ٢٥٠جنيهًا مصريًا | ٢٠جنيهًا مصريًا | ٤٠جنيهًا مصريًا |
| ٤ | أعضاء هيئة التدريس من كافة أقطار الوطن العربي | ١٠٠ دولار أو ما يعادلها | ٥ دولارات أو ما يعادلها | ١٠ دولارات أو ما يعادلها |

**<u>ملحوظة</u> : تسترد مبالغ النشر في حالة عدم قبول البحث للنشر، بعد خصم قيمة التحكيم والمراسلة (٢٥٠ جنيهًا)**

## ❖ سادسًا :اشتراكات الحولية

**قيمة الاشتراك السنوي للعدد الرئيسي كما يلي :**

**من داخل جمهورية مصر العربية :**

- **للأفراد ٥٠ ج.م**
- **للمؤسسات ٧٥ ج.م**

**من خارج جمهورية مصر العربية :**

- **للأفراد ٢٥ دولار، أو ما يعادلها**
- **للمؤسسات ٥٠ دولار، أو ما يعادلها**

**☒ عنوان المراسلة :**

**ترسل جميع المراسلات باسم رئيس تحرير الحولية على العنوان البريدي التالي:**

- **جمهورية مصر العربية- محافظة بني سويف- كلية الآداب- رئيس تحرير حولية كلية الآداب.**
- **أو عن طريق فاكس رقم : ٠٨٢٢٣٢٨٨٥٧**
- **أو عن طريق البريد الإلكتروني التالي:**

**artsbsu_Anuual@yahoo.com**

# Conservation of a Coptic Textile Fragment from the Late Roman Period in Egypt

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## مستخلص:

تتناول الدراسة الحالية الطرق المختلفة المستخدمة لفحص وعلاج قطعة من النسيج القبطي تعاني العديد من مظاهر التلف، خاصة مادة الغراء الحيواني المستخدم في لصق الأثر على لوح زجاجي. يعود الأثر موضوع الدراسة إلى القرن ٣-٤م. وهو محفوظ في مبنى المقتنيات التراثية بالمتحف الزراعي في مصر. تم تقسيم الدراسة إلى ثلاثة أجزاء: أ) فحص وتحليل الأثر موضوع الدراسة باستخدام-SEM-EDAX, USBDM, MALDI-TOF MS, FTIR، والذي بيّن أن الأثر يعاني من العديد من مظاهر التلف، منها الاتساخات، البقع، القطوع، التمزقات، لاصق الغراء الحيواني، أجزاء مفقودة، الهشاشية والحموضة المرتفعة. ب) التجارب المعملية التي استهدفت البحث عن طريقة مثلى لإزالة لاصق الغراء الحيواني من نماذج مقلدة تشبه الأثر، وقد بيّنت أن استعمال انزيم البروتيز تركيز 20 U/mL هو الأفضل. ج) الجانب التطبيقي، والذي ركّز على علاج الأثر موضوع الدراسة، والذي تضمن التنظيف الميكانيكي والكيميائي للأثر، ثم إزالة لاصق الغراء الحيواني باستعمال انزيم البروتيز تركيز 20 U/mL، ثم الغسيل الكلي للأثر، ثم التجفيف في درجة حرارة الغرفة، ثم أخيراً تثبيت الأثر على حامل كتاني جديد.


**الكلمات الدالة:** *نسيج قبطي، فحص، تحليل، صيانة، علاج، إنزيم البروتيز.*

## Abstract:

**The present study addresses the different methods of examination and treatment of a Coptic textile fragment suffers from many deterioration forms, especially the ancient animal glue adhesive used in adhering it to a glass board. The case study dates to the 3rd-4th century. It is located in the Heritage Collections Gallery at the Agricultural Museum in Egypt. The study is divided into three parts: a) The investigation and analysis of the case study object using SEM-EDAX, USBDM, MALDI-TOF-MS, and FTIR revealed that the object had many deterioration forms, e.g. soiling, stains, tears, animal glue adhesive, missing parts, fragility, and high acidity. b) The in-vitro experiments aiming at finding out how best to remove the animal glue adhesive from a simulated mock-up showed that using 20 U/mL protease enzyme is the most potent concentration. c) The applied part focused on the treatment of the case study. It comprises the mechanical and chemical cleaning of the object, removal of the ancient animal glue using warm water poultices and 20 U/mL protease enzyme hereafter, washing the entire object with water and neutral soap, drying in room temperature, and finally supporting it with a new linen fabric.**

**Descriptors:** ***Coptic Textile, Investigation, Analysis, Conservation, Treatment, Protease enzyme.***

## الاستشهاد المرجعي:

**Nabil Mabrouk (2018).** ***Conservation of a Coptic Textile Fragment from the Late Roman Period in Egypt.*** **-- Annual of the Faculty of Arts. Beni -Suef University. - Special Issue.- (January 2018 )Pp: 13 - 52**

# 1. Introduction:

The term 'Copt' is generally understood as an abbreviation of the Greek term '*Aigyptios*' that means Egyptian. After the 7th century AD, the Egyptians who gradually transferred to Islam were called 'Muslims', but those who remained Christians were called *'Gupti'*. This term now has no religious connotations. It only refers to the period between the Pharaonic era and Islamic times () (Rutschowscaya, 1990, Hooft et al., 1994).

Coptic arts began in Egypt around the 3rd century BC, after Alexander the Great's conquest of Egypt in 332 BC. Coptic textiles generally include all types of complete objects, e.g. tunics; fragments, such as tunic ornaments or parts of cloaks; hangings; covers for cushions…etc. Their stylistic patterns of decorations include plants, animals and sometimes humans (Thompson, 1971). Therefore, the ornamental elements of the Coptic textile can be artistically divided into three categories: the Greco-Roman, the transitional, and the Coptic (Michael, 2016). The Coptic textiles were often woven in the 'tapestry' technique; a term derived from the French word '*tapis*' meaning a carpet. Currently, the term denotes the woven wall hangings. The term '*kilim*' denotes the rug weave when speaking about carpets (Gillow & Sentance, 2005).

The problem of the study has been defined in the case study object, which was glued in the past with animal glue adhesive. Thus, soiling the case study is the main challenge to the conservation procedures. Animal glue is one of the most common adhesives in conservation works. In the past, non-professionals used it in gluing most of the archaeological objects. It became hard, rigid, and brittle over time, resulting in physical and mechanical damage to textiles (Balazsy & Eastop, 1998).

Warm water is the most conventional material in the removal of ancient animal glue from archaeological textiles. In addition, enzymes such as protease, pepsin, and trypsin are efficient methods that proved a standing success in the removal of ancient animal glue form archaeological materials, especially textiles (Landi, 1992, Balazsy & Eastop, 1998, Ahmed & Kolisis, 2012). The experiments of the present study use warm water and different concentrations of protease enzyme in the removal of that ancient animal glue adhesive from simulated mock-up samples to find out how best to remove this adhesive. They may help remove the adhesive from the case study heritage object.

The unavailability of the non-invasive techniques used in heritage investigation and analysis was one of the main drawbacks the study tackled. These techniques are only available abroad, not in Egypt. Furthermore, taking any heritage object out of the Egyptian museums is prohibited. Thus, one is obliged to collect small macro-samples form the case study for investigation using other invasive and micro-destructive methods.

# 2. Materials and methods:

## 2.1. The case study object:

The case study object (fig.1) is a Coptic textile fragment in the Heritage Collections Gallery at the Agricultural Museum in Dokki, Egypt. It is documented as object no. 327/14. It measures 27×14 cm. Its main weave structure is the tapestry technique (plain 1/1), with beige and reddish-brown wefts, 8 warps/cm, and 30 wefts/cm. The ornaments are depicting continuously modified crosses inside geometrical alternating designs between two straight beige and reddish-brown borders. The upper border connects many abstract symbols depicting small modified riders, fishes, and portraits. The lower border attaches straight repetitive small medallions connected in a geometrical form. It dates back to the 3rd-4th century owing to its features, style designs, colors, and weaving technique. Comparing its stylistic features to other well-known Coptic textiles, the case study is suggested to be a part of a Coptic tunic cut by an amateur archaeologist or looter. It had many deterioration forms, e.g. soiling, stains, tears, missing parts, fragility, high acidity, fault treatments, color changes, and ancient animal glue adhesive (fig.2).


Fig.1 The case study textile fragment, a. front, b. verso

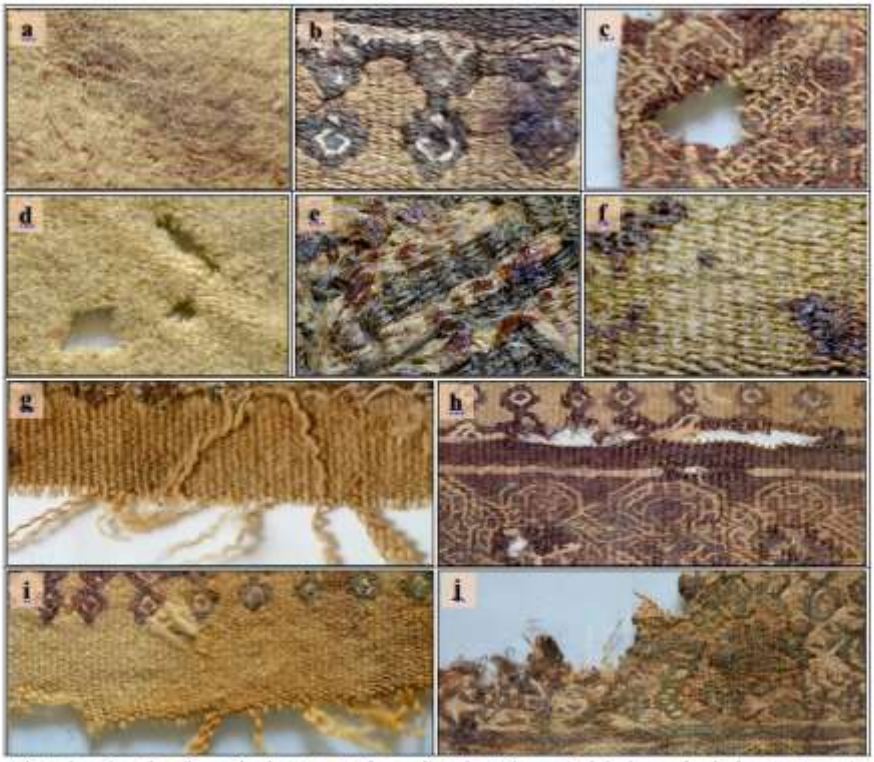



Fig.2 deterioration forms in the case study; a. dust, b. stain, c. & d. holes and missing parts, e. & f. ancient adhesive, g. ravel of wefts, h. longitude tear, j. color changes

## 2.2. Investigation and analysis:

### 2.2.1. Microscopy techniques:

The study used the USB digital microscope (USBDM; monocular type, 0.3m CMOS Sensor, up to 640×480 resolution, 15-40mm focus range, 50-500× magnification range, adjustable 8 built-in LED white lights on camera head) and the scanning electron microscope (SEM; Quanta 3D FEG, FEI Company, USA) coupled with Energy Dispersive X-ray detector (EDAX) to identify and image the deterioration forms in the case study macro-samples and their types of fibers. Moreover, it utilized the EDAX unit to identify the inorganic components of the macro-samples such as accumulated dust and mordants, if applicable. The samples were mounted on aluminum stubs using adhesive-coated carbon discs. The beam energy was 20 kV to obtain the excitation of all the elements. The acceleration voltage with ETD detector (secondary electron mode) was at 10 mm working distance and a spot size 5.5 (1kV/10pA) with a scale ranging from 10µm to 50µm. The spot size was 7 (20kV/4nA) with a scale of approximately 200µm.

### 2.2.2. Fourier transform infrared spectroscopy (FTIR):

FTIR spectroscopy (Thermo Nicolet 6700 FTIR spectroscopy, USA) was adopted to identify the adhesive type for adhering the textile fragment to the glass board. Moreover, it is exploited to chemically identify the fibers. It could confirm or negate the SEM results based on the deformation commonly notified in the morphological features of the investigated fibers by the SEM. The spectra were obtained in the reflection mode using ATR crystal in the spectral range from 4000 to 400 $cm^{-1}$ with 4 $cm^{-1}$ resolution at room temperature.

### 2.2.3. Mass spectrometry (MS):

To identify the type(s) of dye(s) that were probably used in coloring the object threads, mass spectrometer (Autoflex Speed MALDI-TOF-TOF, Bruker) was used in the identification of the two macro-samples (beige and reddish-brown). The investigated samples were fixed by adhesive tape on the steel plate. The mass spectra were acquired in negative reflector mode. The MS instrument was calibrated before the measurement using a commercial peptide mixture MPep. The instrument was fitted with a standard nitrogen laser (337nm). Moreover, the spectra were processed with Bruker Flex III, Bruker Xtof software and mMass 5.0.1 software.

# 3. Results:

## 3.1. Microscopy results:

The results of both the SEM examinations of the case study macro-samples (fig.3) and the USBDM examinations of the case study surface (fig.4) illustrated the fragility, brittleness, and disintegration of the fibers of the warp, weft, and blank ornaments. In addition, dust soiling accumulated on all fibers. The results of the USBDM showed that the weave structure was the tapestry technique, plain 1/1, with the beige and purple-red weft, 8 warps/cm, and 30 wefts/cm. moreover, the torsion direction was S. They revealed the high yellowing rate in vast areas, confirming the high acidity rate observed by the naked eye, as well as the mass of animal glue adhesive that penetrated and covered the investigated areas.

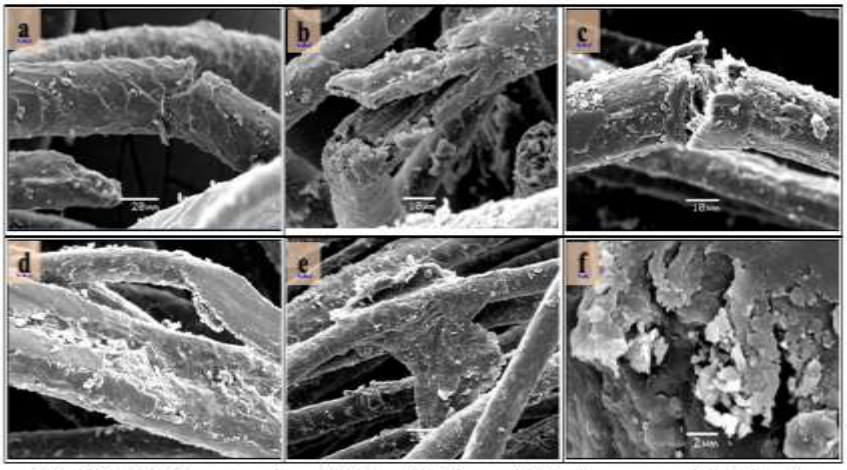



Fig.3 The SEM macrographs; a. friable and brittle wool of the brown warp, b. brittle and disintegrated wool of the beige weft, c. brittle and soiled linen of the blank ornament, d. completely soiled wool of the beige warp, e. glued fibers, f. animal glue adhesive.


Fig.4 The USBDM macrographs of the object surface; a. 1/1 warp and weft weave structure, b. soiling and high acidity, c. glued fibers with animal glue

The high magnification of the SEM revealed that the warp and the weft (beige and reddish-brown) were all from animal wool fibers, but the blank threads used in the ornaments were from linen. The results of the EDAX unit coupled with the SEM of the fibers' examination (reddish-brown weft, beige weft, beige warp, and blank linen) showed many chemical elements, i.e. C, N, O, F, Na, Mg, Al, Si, P, S, Cl, K, Sn, Ca, I, and Fe (fig.5, table 1).

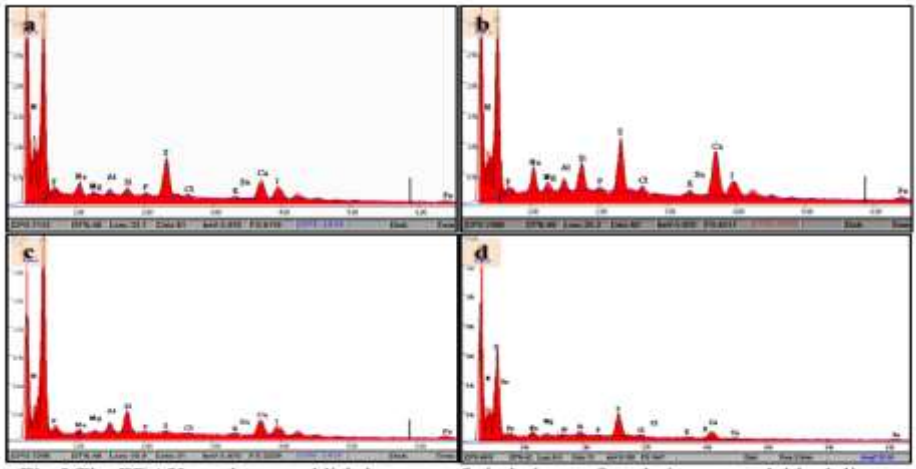


Fig.5 The EDAX results; a. reddish-brown weft, b. beige weft, c. beige warp, d. blank linen.

Table (1) the analytical results of the EDAX unit for the case study macro-samples

| | **Wt% detected elements** | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | C | N | O | F | Na | Mg | Al | Si | P | S | Cl | K | Sn | Ca | I | Fe |
| **Reddish** | 29.5 | 21.1 | 37.5 | 2.7 | 1.1 | 0.2 | 0.3 | 0.3 | 0.1 | 2.1 | 0.1 | 0.1 | 0 | 1.5 | 3.2 | 0.2 |
| **Beige weft** | 29.8 | 17.4 | 34.8 | 2 | 2.1 | 0.5 | 0.7 | 1.3 | 0.1 | 2.7 | 0.4 | 0.3 | 0.2 | 3.5 | 3.5 | 0.7 |
| **Beige warp** | 25.2 | 14.1 | 47.3 | 3.6 | 0.5 | 0.2 | 0.9 | 1.6 | 0 | 0.1 | 0 | 0.2 | 0 | 1.9 | 3.7 | 0.7 |
| **Blank linen** | 36.2 | 21.9 | 35.9 | 0 | 0.8 | 0.3 | 0.2 | 0.3 | 0.1 | 2.2 | 0.3 | 0.2 | 0 | 1.1 | 0 | 0.5 |

## 3.2. FTIR results:

The FTIR spectra of the case study macro-samples (fig.6) revealed that all weft and warp fibers were from wool. While the peak at ~1650 $cm^{-1}$ represented amide I, the peak at ~1545 $cm^{-1}$ represented amide II of the wool. Moreover, the peaks at ~1121 $cm^{-1}$, ~1071 $cm^{-1}$, and ~1040 $cm^{-1}$ represented cysteine and cystic acid; the basic amino acid of the natural wool. The broad peak at 3400 $cm^{-1}$ was attributed to OH due to water molecules absorption (Odlyha et al., 2007, Zhang & Wyeth, 2010). The FTIR spectra revealed that the blank threads used in the object ornaments were linen. The bands at 1316 $cm^{-1}$, 1335 $cm^{-1}$, and 1372 $cm^{-1}$ occurred owing to the COH and HCC bending vibrations. The bands at 1335 $cm^{-1}$ and 1372 $cm^{-1}$ corresponded to the crystalline phase of cellulose, while the vibration at 900 $cm^{-1}$ corresponded to the amorphous phase (Paul & Paul Wyeth, 2003, Paul & Paul Wyeth, 2006).

The FTIR spectra of the adhesive used in adhering the case study to the glass board reported that it was animal glue. The characteristic signals of the amide carbonyl group (–CO–NH–) were identified. While the peak at ~3400 $cm^{-1}$ was attributed to N–H stretching vibration region, the peak at ~1640 $cm^{-1}$ was attributed to the stretching of the carbonyl group (C=O) and the deformation of amide II (–NH2), and the peak at ~1540 $cm^{-1}$ was attributed to the alteration of the material. The peaks at 2852 and 2923 $cm^{-1}$ highlighted the methylene group, and the broad peak between 3000–3750 $cm^{-1}$ showed the hydroxyl and amide

groups. Animal glue is commonly used either in crafting many heritage objects or in repairing the deteriorated ones ( Zorba et al., 2006, Rao et al. 2015).

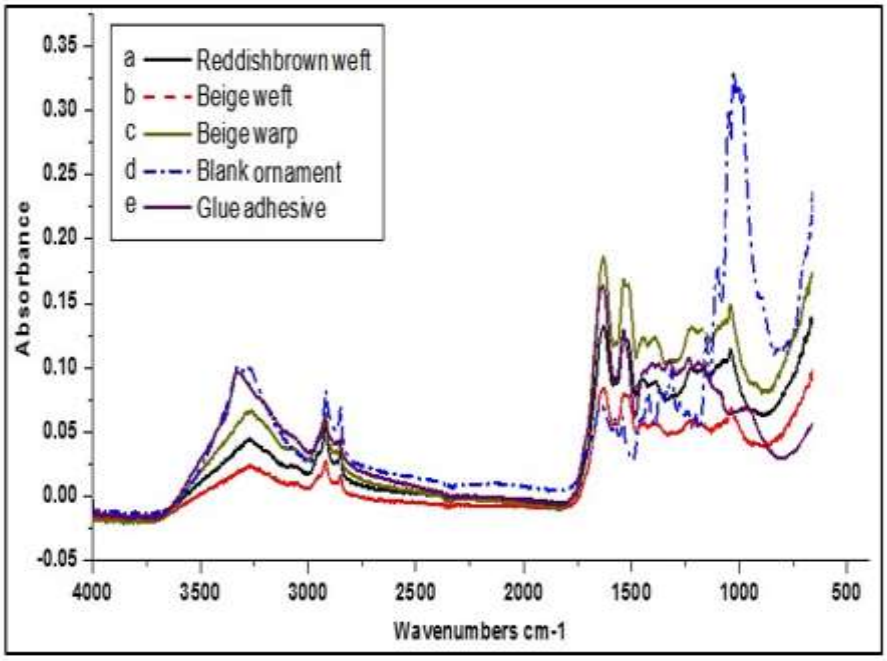
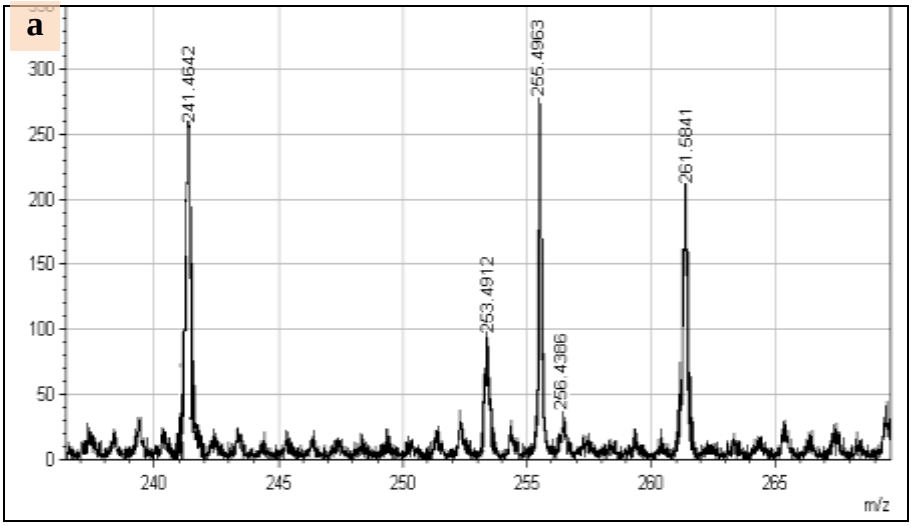



Fig.6 The FTIR spectra of the object macro-samples, a. the reddish-brown weft (wool), b. the beige weft (wool), c. the beige warp (wool), d. the blank ornament (linen), e. the ancient adhesive (animal glue)

### 3.3. MS results:

The MALDI-TOF-MS spectra of the reddish-brown weft fiber (fig.7a) revealed the presence of Alizarin (241 *m/z*), Purpurin (255 *m/z*), Rubiadin (253 *m/z*), and Indigotine (261 *m/z*). Alizarin, Purpurin, and Rubiadin referred to the madder dye, while Indigotine suggested the indigo dye. The spectra of

the beige weft fiber (fig.7b) showed Luteolin (284 *m/z*) and very weak peaks of Alizarin (241 *m/z*) and Purpurin (255 *m/z*). Luteolin indicated the weld dye, while Alizarin and Purpurin referred to the madder dye. The spectra of the beige warp fiber were similar to the above-mentioned ones of the beige weft fiber (fig.7b). They also revealed the presence of Luteolin (284 *m/z*) and a very weak peak of Alizarin (242 *m/z*) and Purpurin (255 *m/z*) (DeRoo et al., 2011, Annemarie et al., 2016, Annemarie et al., 2019).



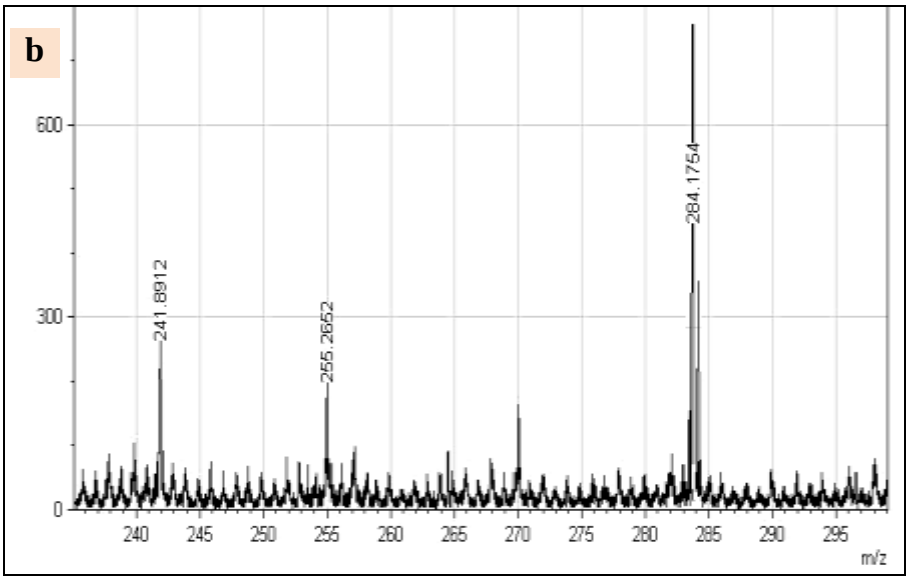



Fig.7 The MALDI-TOF-MS spectra of; a. the reddish-brown weft fiber, b. the beige weft fibers.

# 4. Experiments:

## 4.1. Mock-up preparation:

The wool fabric (Wools Golden Tex Company, Egypt) was prepared by immersing and stirring in distilled water and soap at 50°C for 30 minutes. Then, the fabric was rinsed three times in fresh warm distilled water (50°C) and dried in an oven at 50°C (ASTM- D629, 1999). After that, the samples were dyed with weld concurrently with a trace of madder dyes (Wild Colours Natural Dyes, Birmingham, UK) according to the common dying recipes (Schweppe, 1986, Bechtold et al., 2003). Each woolen sample was separately cut to 3×3 cm slaps, weighed in gram, soiled with around 0.5 gm of a 20% fresh solution of animal

glue, aged in a hot dry oven at 105°C for 72 hours, and kept at room temperature (25°C) for 72 hours (Edward, 2006, Ren et al., 2012) (fig.8).

## 4.2. Cleaning procedures:

Each replica of the soiled and aged mock-up were put in a test tube containing 5 mL of warm water or 5, 10, 20, or 30 U/mL of protease enzyme (from Bacillus Licheniformis, Type VIII, EC No.: 232-752-2, Dostawca POCH S.A) in sodium acetate buffer, pH=7.5, as follows: warm water sample (W1), 5 U/mL protease (P5), 10 U/mL protease (P10), 20 U/mL protease (P20) and 30 U/mL protease (P30). The test tubes were shaken using a rotary shaker (Scientific Industries Roto-Shake Genie) for one hour at 37°C. Thereafter, the textile samples were picked up from the test tubes and washed three times in distilled water at 25°C (Ahmed & Kolisis, 2012, Singh et al., 2012).

## 4.3. Cleaning assessment:

### *4.3.1. Macroscopic and microscopic assessment:*

The results of the USBDM and the optical observation of the experimental samples before and after treatment (fig.8) revealed that some animal glue adhesive still soils the woolen threads. Moreover, no color changes have occurred in W1 samples. P5, P10, P20, and P30 samples achieved an increasingly better removal of the glue adhesive, but with little increasingly color changes.

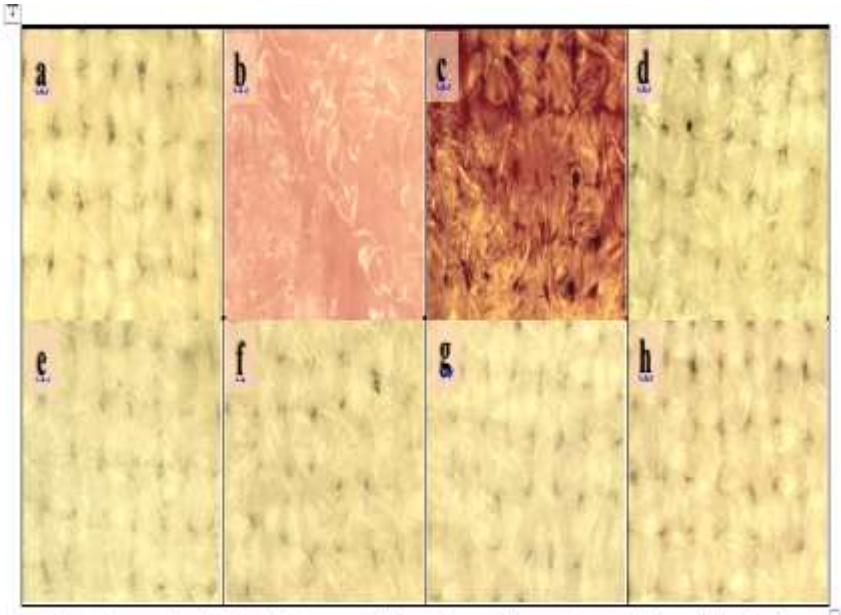



Fig.8 Photographs of animal glue removal from the woolen samples; a. before gluing, b. after gluing, c. after aging, d. W1, e. P5, f. P10, g. P20, h. P30

### *4.3.2. Weight:*

To identify the amount of removed glue by the cleaning agent, each replica was weighed before gluing, after gluing, and after cleaning. The results are detailed in table 2. Each replica lost a different amount of the glue deposited in and on the fibers. This amount increased gradually by increasing the amount of the enzyme. W1 kept on much amount of glue. The percentage of removed glue was calculated, as follow:

$$\frac{\text{sample's weight after gluing} - \text{sample's weight after cleaning}}{\text{original weight of soiling glue}} \text{ X } 100$$

Table (2) Weight of Fabric and glue samples before gluing, after gluing and after cleaning

| Sample | | W1 | P5 | P10 | P20 | P30 |
|---|---|---|---|---|---|---|
| Cleaning agent | | Warm water | Protease 5U/mL | Protease 10U/mL | Protease 20U/mL | Protease 30U/mL |
| Samples' weight gm | Before gluing | 3.24 | 3.45 | 3.32 | 3.21 | 3.34 |
| | After gluing | 5.48 | 5.6 | 5.55 | 5.51 | 5.43 |
| | After cleaning | 4.37 | 4.02 | 3.77 | 3.52 | 3.41 |
| Glue's weight gm | Original soiling glue | 2.24 | 2.15 | 2.23 | 2.3 | 2.09 |
| | Removed glue | 1.11 | 1.58 | 1.78 | 1.99 | 2.02 |
| % of removed glue | | 49.55 | 73.48 | 79.82 | 86.52 | 96.65 |

### *4.3.3. Colorimetric measurements:*

The experimental samples were dyed with weld concurrently with a trace of madder dyes. The color changes between the reference sample (dyed and aged sample) and the cleaned samples were measured by the spectrophotometer (DR LANGE MICRO COLOR LDC20-II) to evaluate the probable color changes that might occur due to cleaning agents (table 3).

Table 3 Colorimetric measurements of the treated samples

| **Sample** | | **W1** | **P5** | **P10** | **P20** | **P30** |
|---|---|---|---|---|---|---|
| **Cleaning agent** | | Warm water | Protease 5U/mL | Protease 10U/mL | Protease 20U/mL | Protease 30U/mL |
| **Colorimetric measurements** | **ΔL*** | 5.16 | 7.92 | 8.74 | 9.43 | 11.32 |
| | **Δa*** | -0.83 | -2.32 | -3.53 | -4.62 | -6.13 |
| | **Δb*** | -0.19 | -0.51 | -0.86 | -1.02 | -1.68 |
| | **ΔE*** | 5.22 | 9.46 | 8.26 | 12.98 | 15.39 |

### *4.3.4. Spectroscopic assessment:*

FTIR spectroscopy was used in investigating the cleaned samples (W1, P5, P10, P20, and P30) and the reference sample (dyed and aged wool sample). This assessment aimed at identifying any glue residue in the fibers. The results (fig.10) revealed that the P20 and P30 spectra were the most similar ones to the reference dyed and aged woolen sample. W1 spectra showed strong and sharp absorption due to the huge amount of glue residue. The results highlighted many similarities in all

spectra because all components (the fiber and the glue) are protein. It would be easier to distinguish if both were of different materials.

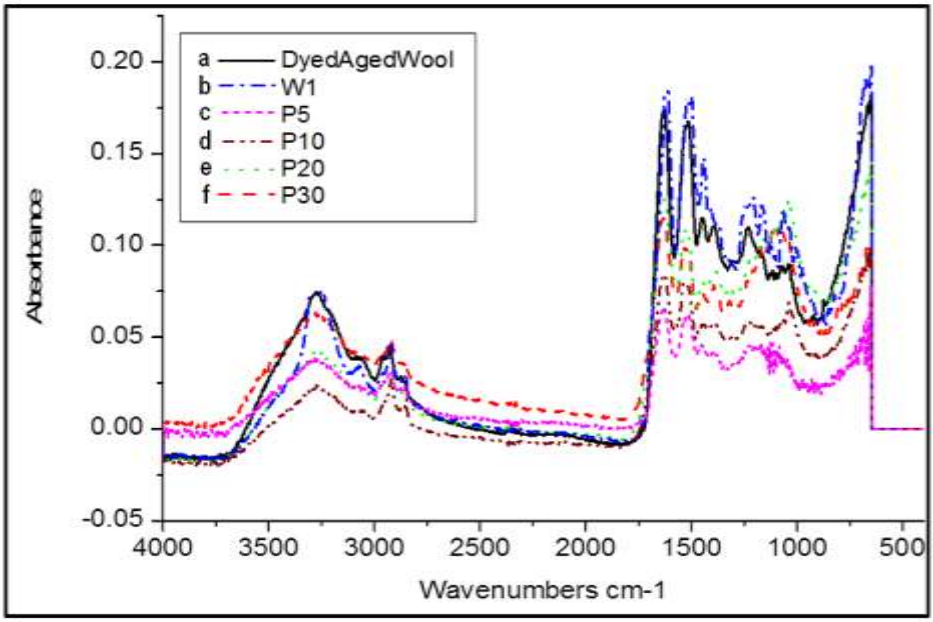



Fig.10 FTIR spectra of the mock-up samples before and after glue removal; a. dyed and aged wool, b. W1, c. P5, d. P10, e. P20, f. P30

## 5. The case study treatment:

### 5.1. Mechanical cleaning:

A soft brush was carefully used to loosen and eliminate the different contaminations and soiling dust on the surface and inner parts of the threads and fibers. Then, a small handy blower was utilized for the suction of the loose contaminations and soiling dust (fig.11) (Landi, 1992, Finch & Putnman, 2002).

Fig.11 A part from the case study object before and after mechanical cleaning

## 5.2. Removal of the animal glue adhesive:

Based on the results of the experiments, it was preferred to start the removal of the animal glue adhesive by a poultice of the adhesive-soiled spots by warm water for one hour. This step aimed at softening the adhesive in a green method to facilitate and assist the use of protease enzyme later, and to minimize the time of enzyme reaction with the fibers. It is recommended not to prolong the enzyme application to heritage objects. After softening the glue, the softened outer parts were mechanically removed one by one. Thereafter, the protease enzyme (20 U/ml at 37°C) was used in cleaning the animal glue residues in the glued spots that were directly rinsed stepwise by distilled water to remove the excess enzymes from the fibers (fig.12) (Decoux, 2002, Ahmed & Kolisis, 2012).

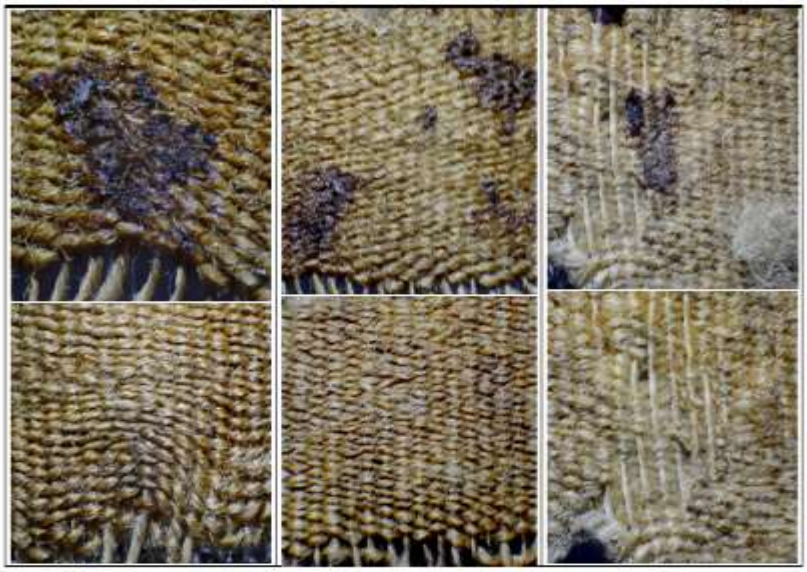


Fig.12 Photographs of animal glue adhesive in the case study, before and after removal

## 5.3. Washing and drying:

It was decided to wash the case study for many reasons: 1) The dust residues, which probably still soil the inner sections of the case study; 2) The high acidity rate spreading in the case study that requires water at least to be neutralized; 3) The brittleness and dehydration of the object fibers; 4) Treating some spots with protease enzyme and distilled water and the untreated areas should physically and chemically match the treated ones; 5) The positive results of washing fastness of the dyed threads against water and neutral soap. All these results motivated the author to wash the case study object.

A bath of distilled water and 1% neural soap was prepared and poured into a washing tray. The object was gradually humidified with distilled water using a hand sprayer. Thereafter, the object was carried upon a tulle fabric and put into the wash bath. It was soaked in the bath for 20 minutes, then gently pressed by hands to extract the interior dust. After that, the wash bath was replaced by a fresh similar one, then replaced by three sequential rinsing baths containing distilled water. The object was then lifted from the wash tray and put upon a towel to absorb the excess water. All distortions were fitted in the right directions and kept until complete dry at about 25°C (fig.13) (Yvonne, 1990, Landi, 1992, Mauro et al., 1999.

Fig.13 Washing, drying and straightening of the case study object

## 5.4. Supporting:

Due to the brittleness, fragility, and scattered and unregulated threads of the case study object, it was suitable to support the object on a new linen fabric, as follows (Landi, 1992, Balazsy & Eastop, 1998, Lennard, 2006):

1. Preparing a 37×24 cm wooden frame painted by polyurethane varnish as a precaution procedure to overcome the probable humidity.

2. Washing a 47×34 cm linen fabric in boiled water and commercial soap for 30 minutes, then drying and ironing it.

3. Stretching and pinning the linen fabric on the wooden frame.

4. Initial fixing of the object to the linen support.

5. Half backstitching of the whole object on the linen fabric in crossed rows vertically and horizontally from the inner to outer parts. Thin needles and naturally dyed silk threads with the suitable colors were used.

6. Using basting and herringbone stitches in the holes and rupture areas, respectively (fig. 14).

Finally, the case study object was redisplayed in its showcase.


Fig.14 Supporting the case study object on a new linen fabric; a. the linen support stretched on a wooden frame, b. sewing a lost area with the basting stitch, c., sewing a rupture with the herringbone stitch, d. sewing an edge with the basting stitch, e. the case study after treatment

## 6. Discussion:

The case study object is a Coptic textile fragment that dates back to the 3rd-4th century in Egypt according to the museum's records. The stylistic designs, ornamentations, colors, and weaving techniques confirm the archaeological dating of the object (Thompson, 1971, Keijzer et al., 2007). The comparison of the artistic features and weaving techniques of the case study with the other Coptic textiles revealed that the case study was a cut part from a Coptic tunic. Most of the Coptic textiles were collected by some amateur archaeologists or looters who often deformed the archaeological contexts (Hooft et al., 1994, Gillow & Sentance, 2005, Thomas, 2007). Thus, it was highlighted why some edges of the case study appeared sharp although there were no hems.

The results of the different investigation and analysis methods confirmed literature about the historical materials and methods of Coptic textile fabrication in the Late Roman Period in Egypt. The weave structure was the plain tapestry, S torsion threads, fibers were from natural sheep wool and linen (Keijzer et al., 2007, Ahmed, 2017, Karydis et al., 2019). Weld and madder trace dyes were identified in the yellow dyed fibers (Wouters, 1993, de Graaff, 2004). The apparent reddish-brown color isn't genuine, it is confirmed as a purple red color. The Coptic craftsmen generally dyed the woolen fabric and threads with the indigo/woad dye, then with the madder dye to obtain that lovely

so-called color ‘Egyptian Purple' (Cooksey, 2001, Cardon, 2007, Keijzer et al., 2007). This result of the chemical analysis was confirmed by another result of the physical investigation using the USBDM.

The results of the EDAX unit coupled with SEM revealed the presence of C, N, O, F, Na, Mg, Al, Si, P, S, Cl, K, Sn, Ca, I, and Fe in most of the investigated fibers. Most of these similar elements in all samples represent soil and accumulated dust. If one tries to find a mordant, it should be identified only in the dyed fibers, not in the blank one. Other studies commonly identified most of these elements in the Coptic textiles (Trojanowicz et al., 2004, Ahmed et al., 2017, Amin, 2019). Most of the identified elements, such as O, Na, Mg, AI, Si, P, Cl, K, and Ca could be due to the contaminations from the archaeological sites. It is unacceptable to attribute them to the chemical elements of the mordant (Trojanowicz et al., 2004). Sn was identified in only the beige weft. Thus, it might suggest stannous chloride mordant, especially, Cl element that was also identified. The high intensity of C, N, O, and S suggested the major components of wool (Solongo et al., 2017). In the same context, it is impossible to confirm using any mordants; all elements were identified in all investigated fibers, either dyed or not. Therefore, all the identified elements could be attributed to the wool ingredients and the case study environment.

The obtained results revealed many deterioration forms in the case study, especially the brittleness, fragility, and yellowing.

These forms were confirmed by the FTIR results, where all the analytical spectra of the case study highlighted the evolution of cysteic acid at 1040 cm-1 and variant changes in the Amide I, II, and III peaks (Carr & Lewis, 1993). These degradation and yellowing forms were due to many factors, such as the ill-adapted environment in the Agricultural Museum, the internal factors, and the human factors; not a single cause only (Cooper, 1987, Odlyha et al., 2007). Some studies attributed the well-preserved Coptic textiles to the dry burial soil in Egypt (Karydis et al., 2019), but the major alteration of the purple-red color to a pale green one at the lower-right area of the object was absolutely caused by a very harsh and strong chemical, either in the ancient storage or in a burial soil. The FTIR results illustrated significant decrease in the absorption band intensities of the archaeological samples compared to the modern ones, owing to the hydrolysis and oxidation reaction (Tomńič et al., 2007, Kavkler & Demńar, 2012).

The results of the samples' weight showed that the minimum amount of the removed glue resulted from using warm water. It improved gradually by increasing the concentration of the protease enzyme. These results point out that warm water is not efficient enough to remove the aged animal glue adhesive. On the contrary, the protease enzyme was more efficient and could completely remove the aged animal glue adhesive, especially in the high concentrations. Colorimetric measurements showed a gradual increase in the color changes of the cleaned samples by

protease enzyme along with the increase of protease concentration. These results were confirmed by the FTIR spectra and the microscopic and macroscopic results. To conclude, warm water is a very delicate and completely safe material in the removal of animal glue, but not efficient enough. Protease is more efficient but more harsh and harmful to the fibers (Ahmed & Kolisis, 2012, Singh et al., 2012).

## 7. Conclusion:

The case study object is a Coptic textile fragment dating back to the Late Roman Period in Egypt. It showed many deterioration forms, especially the animal glue adhesive used in adhering it to a glass board. Therefore, the experimental part of the study was dedicated to identifying how best to remove this ancient animal glue adhesive. The results revealed that the warm water is insufficient to completely remove the animal glue adhesive, while the protease enzyme is more efficient but more harsh to the woolen fibers. The study recommends using warm water poultices, preceding to the protease enzyme to initially soften the adhesive and to facilitate the using of protease enzyme hereafter. It is important to decrease the reaction time between the enzyme and the fibers as possible. The study suggests that preserving the heritage object, even with some deterioration forms, is preceded upon the removal of deterioration forms.

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