

## Summary

The ancient textiles are greatly important. They present marks of the interaction between man and the environment elements surrounding him.

The importance of heritage restoration is to keep its treasures revealing the ancient secrets over the years.

In this study between your hands, we benefit from the experience of the former researchers from theoretical information or scientific experiences, in addition to what we have achieved in the experimental studies aimed to the protection of our textile heritage from the experimental attempts which if it succeeded once, it would fail other times.

Through this experimental side, we have gathered a lot of results which we made benefit from it in restoration of two pieces of textiles in a museum in the faculty of Arts, Alexandria University.

This study is divided into five chapters as follows:

### **The first chapter:**

Under the title of "the used fiber in the industry of the ancient textile, its nature, its composition, its deterioration factors and deterioration features".

As we have in this chapter, the important fibers which are used in the industry of the ancient textiles over historical years are as follows:

First: the vegetable fibers, they are divided into:

- a) Bast fibers such as flax, kapok, hemp and jute.
- b) Leaf fibers such as sisal.
- c) Seed fibers such as cotton and kapok

Second: protein fibers, they are divided into

- a) Wool fibers
- b) Silk fibers

This study has considered every kind of fibers from its physical and chemical properties in details.

This was followed by the most important deterioration factors and deterioration features of textile fibers.

Understanding the physical and chemical nature of fibers is an important basis in understanding the mechanism of the fiber damage. Then it studied the chemical structure of fiber polymers with a bit of details.

After that it studied the fibers damage and the effect of the damage on the chemical and mechanical properties, then the important factors that affect textile fibers damage, for example: the damaging effect of electromagnetic radiations, the temperature, the humidity, acids and alkalis. Also it talked about the most important deterioration features and the dirt of the ancient textile, its identification and classification.

They were classified according to its source, its potential for damaging the textile, its shape, removal methods, and solubility in the different materials.

I talked about the adhesion forces between soiling and textile, and their importance in cleaning, either wet cleaning or dry cleaning.

## **The second chapter**

It is under the title:

"The different ways of cleaning the ancient textiles, air cleaning, humid cleaning and dry cleaning".

It talked about the dry cleaning in detail. This was because it is put in a comparison with cleaning by enzymes to remove the fatty dirt. Here are some of the Details to what we talked about:

First: air cleaning

Second: the humid cleaning

It explained the importance of water as a dipolar solvent and the advantages and disadvantages of its uses. I talked about the surface tension of liquids and how to reduce it through using surface active agents, the most important kinds and how to use it in cleaning the ancient textiles.

The dry cleaning, I talked about it in detail, including its definition and the most important cases in which it is applied. In addition to the measures which control its uses and the application methods of organic solvents cleaning which are divided into

a) Cleaning by submerging the ancient textile in the organic solvents.

b) The positional cleaning by using the organic solvents.

It studied the division of the organic solvents and the factors which limit the solubility of dirt.

We also studied how to benefit from fractional solubility parameters and the triangle diagram of the solvents in the dry cleaning in detail because it plays an important role in determining the best choice of the organic solvent to remove the dirt.

And we talked about the practical application of fractional solubility parameters and the triangle diagram in cleaning the ancient textiles.

We did not forget to add a table showing the most important organic solvents to remove most dirt in the ancient textiles.

### **Chapter three**

Under the title "enzymes, its nature, its importance, its division and how to benefit from it in the conservation work".

In this chapter we talked about the enzymes definition and how they were discovered.

This was followed by introducing a proof of enzymes protein nature, and the changes it experiences as a result of a temperature and pH value changes. Also, we considered the role of enzymes as biocatalysts.

It explained how the enzymes catalyze and reduce the activation energy which is needed to complete the reaction and so it increases the speed of the reaction millions times.

Also it talked about enzymes naming and classification in detail as follows:

a) General classification:

It was based on naming enzymes by trivial name, before any attempts to develop the naming methods and systems.

b) Classification based on composition. It depended on the following enzymes classification:

1- Enzymes consist of only protein nature.

2- Enzymes consist of protein and coenzymes.

c) Naming and classification according to the international union of biochemistry.

The enzymes were divided into six groups in 1955 as follows:

The first group: Oxidoreductases.

The second group: Transferases.

The third group: Hydrolases.

The fourth group: Lyases

The fifth group: Isomerases

The sixth group: Ligases

d) The naming and classification system according to the enzymes international committee system. The naming and classification of enzymes in 1964 happened according to the naming from enzyme commission.

It is known as the digital system for the enzymes. It is considered as the code number to each enzyme, E.C is usually written before it.

This number consists of four numbers, a dot separate among them; the first number from the left side refers to the group which the enzyme belongs to, the second number refers to the class which the enzyme belongs to, the third number refers to subgroup, while the fourth number refers to the serial number to each enzyme.

After that the study talked about the enzymes specifications which are considered the most distinguished qualities of the enzymes.

It also talked about the factors which affect the enzymes activity which can be represented in:

- a) The effect of temperature.
- b) The effect of enzyme concentration.
- c) The effect of reaction time.
- d) The effect of substrate concentration

It gave a historic view on the enzymes uses in cleaning, from prehistoric we reach until to the modern ages.

Then it talked about the most important enzymes which we can use in the conservation.

### **The fourth chapter, "The experimental side"**

We talked in this chapter about the experimental side of the study.

We used samples of pure textile to be similar to ancient textiles in its nature and its conditions, a desire of us to get scientific results near to the fact and the accuracy through which we can avoid the risks of the experiments which may be wrong and may be correct.

We used pure textile as following:

- a) Pure flax textile from the production of Maneztex Company in Alexandria.
- b) Pure textile cotton from the production of Egypt Company in Mahalla Elkobra.
- c) Pure wool textile from the production of Goldentex Company in the city of tenth Ramadan.

We prepared the samples with the suitable measurements to do the tensile and elongation testing.

After that, we performed accelerated aging to these samples, to achieve two purposes:

- a) Bringing the modern textiles to a state of weakness similar to ancient textiles.

This was performed to give experimental results similar to the application results

on the ancient textiles to study the relation between the age of dirt and the efficiency of cleaning it.

The samples were exposed to a temperature of 130° in different periods to perform artificial aging.

we measured the tensile strength and elongation of the samples in each period of time; this was followed by tabulating the results and representing them in schematic diagrams to be followed up easily.

After that, it studied the dyeing with cochineal dye as one of the most important natural used dyes.

We tested the stability of cochineal dye in different pH values. The experiments aimed to study the effect of acid and base on color dampness of the woolen and cotton samples which were dyed with cochineal.

It talked about the uses of enzymes in cleaning; we placed three kinds of dirt: fats, protein and starch alone on the textile samples of cotton and flax.

After that we added compound dirt composed of fats, protein and starch. This was to study how to deal with the enzymes in a suitable way to clean the compound dirt.

I used the Lipase enzyme to clean the fats stains;  $\alpha$  amylase enzyme and Diastase enzyme were used to clean the starch stains. While Pepsin and Trypsin enzymes were used to clean the protein dirt.

The compound dirt has been cleaned by the previous three enzymes, but in a suitable scientific order in order not to affect each other as the study explains in detail.

### **The fifth chapter, "the application side"**

In this chapter I introduced a general view on Coptic textile. This was because the two ancient pieces under experimenting belong to the Coptic textile, and because the textile industry flourished greatly in the Coptic age, it extended from the 1<sup>st</sup> to the 9th century A.D.

The Coptic textiles:

We talked about the tapestry textile in details; its naming and the most important advantages and raw materials which were used in its industry. Also we considered the decorative shapes on those textiles. I benefited from the results of the experiments for applying the cleaning enzymes on two ancient textile pieces in the museum of the faculty of arts in Alexandria University, and making a complete restoration plan including stitching and museum displaying as a part of the study.

**First:** the ancient piece number 1380. I described the textile piece. It is a piece of flax textile. There are two decorative stripes on it with a tapestry technique and a

lot of dyes. It was analyzed technically to know the textile fabric structures, detect the textile structure and the warp fibers and the weft fibers in the centimeter square. In the scientific investigation and analysis, we investigated the longitudinal view to every kind of the used fibers in the piece using scanning electron microscope to detect its kind.

Also, IR absorption and reflection analysis was used to limit the kind of dyes which were found in the piece, while X-ray diffraction analysis was used to know the kinds of mordant.

To detect the kind of the suitable enzyme, it was important to identify the kind of the dirt in the piece. This can be done by using IR absorption and reflection analysis. The ancient piece was put between two plastic nets so as not to be harmed during washing by water which we performed at first to get rid of water soluble dirt. This was followed by preparing the buffer enzyme solution. Little of Arabic gum solution was added to it, to work as a fat emulsifying material, to facilitate cleaning fatty dirt. The enzymes were applied in the form of cotton compresses to the textile piece. After that, the piece was washed to get rid of the loose dirt and ensuring the final getting rid of the enzyme, then ninhydrin reagent was used as a test for the enzyme stability and Bradford method was used to test for enzyme remains in washing water. After washing, the piece was dried in room temperature. After that, the piece was prepared for the process of stitching and museum displaying. A wood frame was then prepared in a suitable size to the piece, then it was covered with a raw flax cloth, and then it is fixed from behind with metal nails and put the piece on it and made initial stitching to it. Then a final stitching was done using real silk fibers of the same color of the ancient piece. After finishing the final stitching of the piece, it became ready to the museum displaying.

Second: the piece number 1879. It is an ancient flax shirt with two decorative stripes from the silk fixed to the shirt by using basting stitch from outside and running stitch in the middle. Technical analysis to the shirt was performed to recognize the kind of the textile fabric structures and the number of the warp fibers and the weft fibers in the centimeter square.

Recording the shirt by drawing and photographing was done. Then, the electron microscope was used to examine the shirt fibers to detect their kind through investigating the longitudinal view, and also by using X-ray diffraction analysis. The kind of dirt in the shirt was also specified. The ancient shirt was supported by two plastic nets to protect it from being harmed during washing.

After that I prepared the enzyme analysis which was organized in different pH values after washing and drying the shirt, it was prepared for museum displaying. Because the shirt is three dimensional so a three dimensional show was made. This was through designing a three dimensional stand from a Plexiglas material then it was covered by a raw flax cloth. Then the shirt was placed in a suitable place.

Then initial stitching and final stitching were made by using different stitches by fine silk strings in the same color of the ancient piece. After that, the piece was put into the stage of museum display.