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Original article

AN ANALYTICAL STUDY: IDENTIFICATION AND BIODEGRADATION CHARACTERISTICS OF ANCIENT EGYPTIAN WOODEN PAINTED GRAIN STORE, EGYPTIAN MUSEUM, CAIRO, EGYPT - PART-I

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Abstract

Current study comprises two parts, Part-I, the subject of this paper, contains analytical study of ancient Egyptian painted grain stores using some scientific techniques, The following research (Part –II) deals with the restoration and conservation of the same object. In this paper, ancient Egyptian painted grain stores have been studied, using (Light Microscope - SEM - EDX- X-ray – FTIR - chemical analysis of cellulose, and biological study) in order to determine their mineralogical and chemical composition and evaluate how these pigments were affected by air pollution .Gypsum was detected in the examined plaster and pigments samples which indicates the effect of sulfur as a pollutant on the deterioration of the painted wooden model, The detection of halite in all the studied samples indicates the effect of bad storing . Light microscope was used to identify the type of wood and infection. SEM indicates the effect of fungi and bacteria on the painted wooden grain store, in addition to weakness, cracks, and losing pigments in many parts.

Keywords: *Wood, pigment, deterioration, Biodegradation, XRD, SEM-EDX*

1. Introduction

The ancient Egyptian civilization is one of the oldest and most wonderful civilizations in the world throughout the history. The Egyptian wooden artifacts reflect the skills of the ancient craftsmen [1], where they used local wood as well as the imported timber. The pharaonic period was characterized [2], among many other features, with magnificent wooden artifacts. Model making was known since the end of old kingdom. In the beginning, models were separated and fixed on wooden base without any architectural units [3]. But at the end of the Middle Kingdom (11^{th}-12^{th} dynasty), models became different. Models in that period looked like a box containing a group of servants or craftsmen; their job was to render their crafts or services to the tomb owner [4]. The most significant models in such period was about cultivation and cattle in the field of carving and painting [5], as it was painted with natural pigments on simple background, or the grain store model which is made of three pigment materials, red, black, and yellow [6], but there were other pigments that were used in the same period like blue and green [7]. The coloring pastes were used in inlaying some parts of models [8]. The present paper focuses on grain store model, dating back to the middle kingdom. It presents different activities for storing,

weighing and separating different types of grains. This model has a door on the left side, with a sitting scribe, in the second upper level, holding a pen in his hand to register the amount of grains. This scribe may be also in command of the weighing of grains. In the ground level, there are two men holding some corn measures to load the grains. To the left hand side, another servant carries a sack on his head, as illustrated in fig. no (1). The last figure looks typically like the object of this paper which has No.2/33/9/7 in Egyptian Museum but with one difference, as model no. 2/33/9/7 has two shelves in the second upper level, as shown in fig. no.(2). Our object measure 25 cm width, 50 cm in length and 50 cm height. Model of grains store generally suffers from severe deterioration, due to many causes, such as fungi, like chaetomium, [9] which work on absorbing moisture from wood and causes high brittleness, as well as cracking and the plaster layer and colors falling thereby , rendering the model to be too fragile.

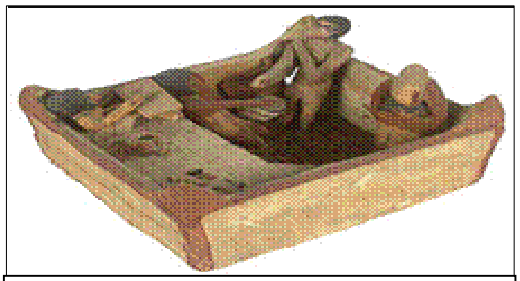

Figure (1) one of grains store models "WWW.eternalegypt.org/fternal Egypt webs \"

Figure (2) model of grains store carrying No.2/33/9/7 In Egyptian museum – Cairo, Egypt

2. MATERIALS and METHODS

A number of modern devices were used to examine and analyze colored wood which was used in building the grains store model. Thus microscopic slides were prepared for examination under light microscope to identify the type of wood used in making the grain store model and biological deterioration (bacteria & fungi). scanning electron microscope SEM was also used to examine and magnify the samples. Analysis was conducted to identify the elemental composition of the erosion products through EDX unit. X-ray diffraction analysis was carried out to determine crystalline materials in model grains store. FTIR was used to identify the binding materials, finally fibers analysis of wood was made.

2.1. *Light microscope*

Some samples were prepared for examination of wood sections, namely, transversal sections and longitudinal sections, as well as identifying the types of bacteria and fungi infections.

2.2. *Scanning electron microscope SEM.*

SEM Philips (XL30) was used for examination of the wood surface through monitoring deterioration of the wood (weakness in the bonding materials between fibers), fungi infection, and color materials.

2.3. *EDX Analysis*

EDX analysis of the pigments and plaster found on the model of grains store was conducted in order to find out the existence of some elements.

2.4. *Fibers analysis*

Quantitative analysis of wood components was determined by chemical analysis through weighting technique.

2.5. *X-ray diffraction analysis (XRD)*

X-ray powder diffraction patterns were obtained using 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. This technique was used to identify the composition of plaster and pigments which were applied on the wooden store corn.

2.6. *Infrared analysis (FTIR)*

FTIR spectra were recorded on a Perkin-Elmer Spectrum GX FTIR system with samples prepared as KBr pellets, in the 4000 to 370 cm–1 range, at a resolution of 4 cm -1. The collected spectra have been expressed by absorbance units and baseline has been corrected. The IR results were performed over the normalized spectra; it was used to identify binding medium and organic materials.

3. RESULTS and DISCUSSION

3.1. *Light microscopic examination*

Light microscopic examination showed that the species of the wood is *Pinus nigra* [10] as shown in fig. (3). The types of bacteria and fungi infection are: *Chaetomium Sp* as show in fig. (4-a). This fungus is commonly found on deteriorating wood products. It is considered as a contaminant, occasionally implicated in a systemic and coetaneous way. It should be considered as allergenic, and it has a heavy hear around the fungus body .Its color is brown .The fungus body has (4-8) germ. [11]. *Penicillium Sp*. is common contaminant on various substances. This organism causes food spoilage and colonizes on leather objects and is an indicating organism for dampness indoors. It produces pink and purple spots on painted walls, as shown in fig.(4-b). *Aspergillus flavus*. It has been isolated more frequently from seeds, other plants and insects. This fungus should be considered allergenic. No invasive diseases have been documented to date as shown in fig. (4-c), in addition to the dominated type of bacteria, it is *Bacellus.Sp* as shown in fig.(5) .

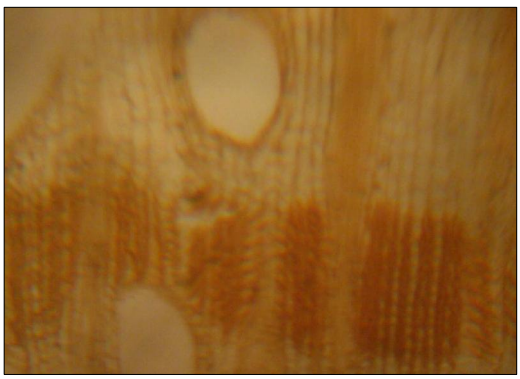

Figure (3) light microscope photo of (T.S) section confirming that the type of the wood is *Pinus nigra (*after, Core, H, 1979)

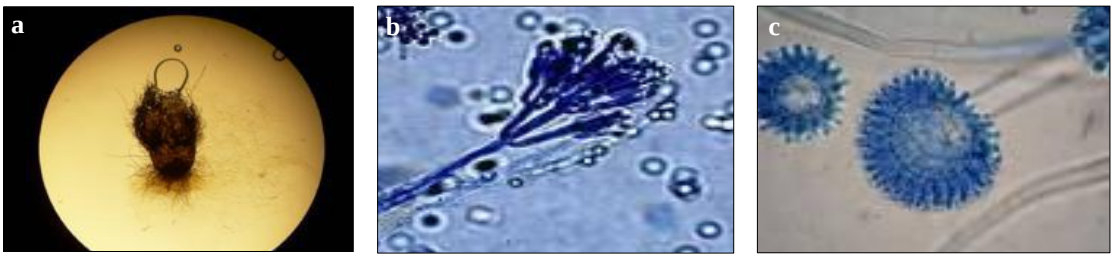

Figure (4) light microscope photos **a** of fungi infection *Chaetomium Sp*., **b** *Penicillim Sp*, **c** *Aspergilus flavus*

Figure (5) light microscope photo of bacteria infection Bacillus Sp. www.moldclean up/mold-typs.htm – 2/2010

3.2. *Scanning electron microscope SEM*

Examination of the wood surface by SEM shows that there are deterioration forms affected the wood (weakness in the bonding materials between the fibers), and fungi infection, as shown in fig. (6-a). On the other hand the plaster surface examination shows deterioration of the plaster (weakness in the bonding forces between the grains as a result of solving binding material), as shown in fig. (6-b). Examination of the red color surface shows (weakness in the bonding forces between the grains as a result of solving binding material), as shown in fig. (6-c).

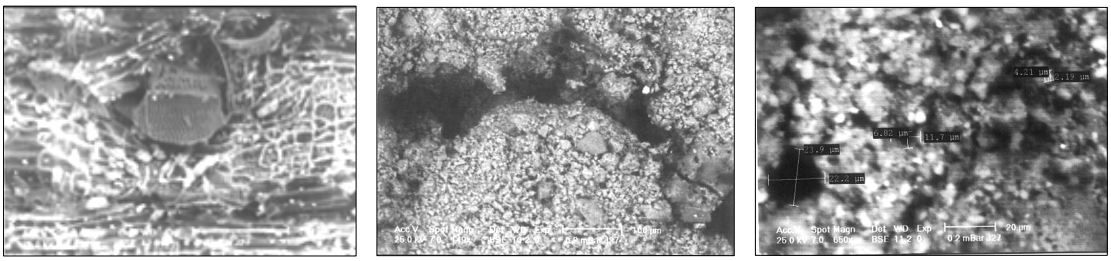

Figure (6) SEM photo of **a** friable wood structure with fungi infection chaetomium 119-182 X, **b** friable plaster and measure of grains with micronX149-650, **c** red color and measure of space between the grain with micron X250.

3.3. *EDX analysis*

EDX analysis shows that the plaster layer covers grain model shown fig.(7-a, b) indicate that the presence of C declares wood rest. The presences of Si, K, O, Al and Fe are essentially owe to calcium carbonate with traces of gypsum as a plaster and hematite as painted layer, and indicative of the existence dusts. In addition, the occurrence of Na, Cl indicative of the existence of Halite. Finally presence of P is sign of the organic rest .

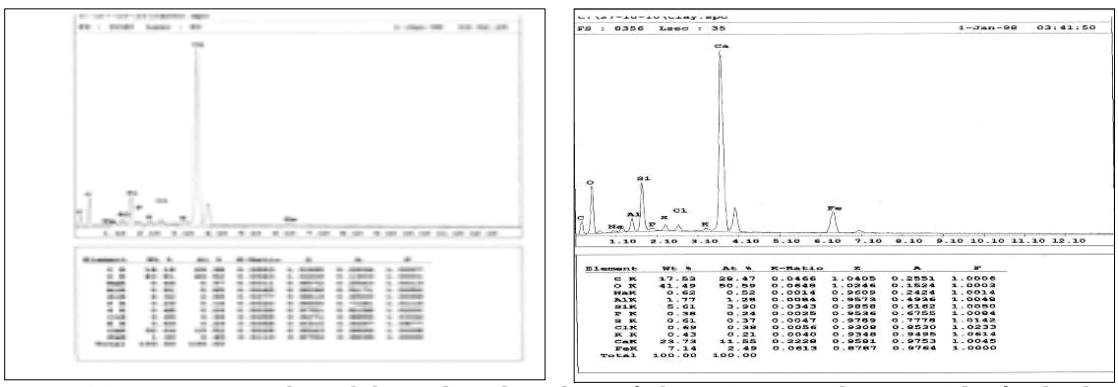

Figure (7) EDX pattern showed the analytical results **a** of plaster (Ca- Si- Al-C-Fe-O_2) **b** of red color (Ca- Si-Al-C-Fe-O_2)

3.4. *Quantitative analysis of the wood components*

Quantitative chemical analysis of wood was conducted in the department of paper, cellulose and wood at National Research Center, Dokki, Cairo, Egypt. Accordingly, wood sample under investigation exhibits cellulose 29% hemicelluloses 38 %, and soot 6%.

3.5. *XRD analytical results*

The results of XRD pattern given in fig.(8) shows the presence of calcium carbonate $CaCO_3$ card no. (5-0586) as a white color and a plaster layer and hematite Fe_2O_3 card no. (13-534) as a red color.

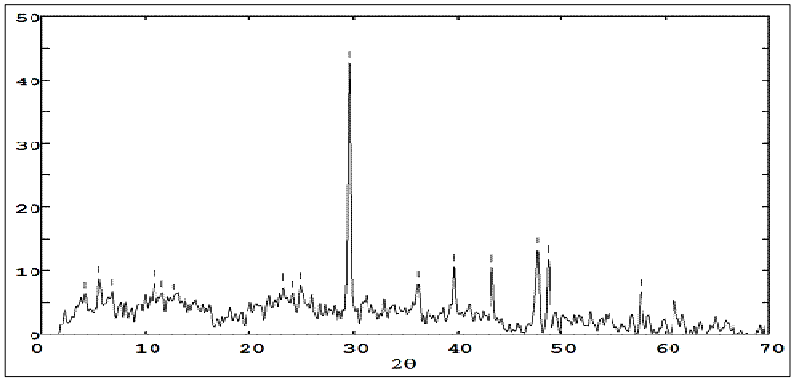

Figure (8) XRD pattern of plaster and colors as follow (Calcite $CaCO_3$) (Hematite Fe_2O_3)

3.6. *FTIR analysis*

FTIR analysis shows that the residue of the bonding material is animal glue, as shown in fig. (9-a, b). It is further classified that the deterioration of the wood (weakness in the bonding material between the fibers, plaster and pigment did occur, as show in fig.(10-a, b, c), microscopic photos (L.S), fig.(11-a), and microscopic photos (R.L.S), fig. (11-b) confirms the weakness of wood .

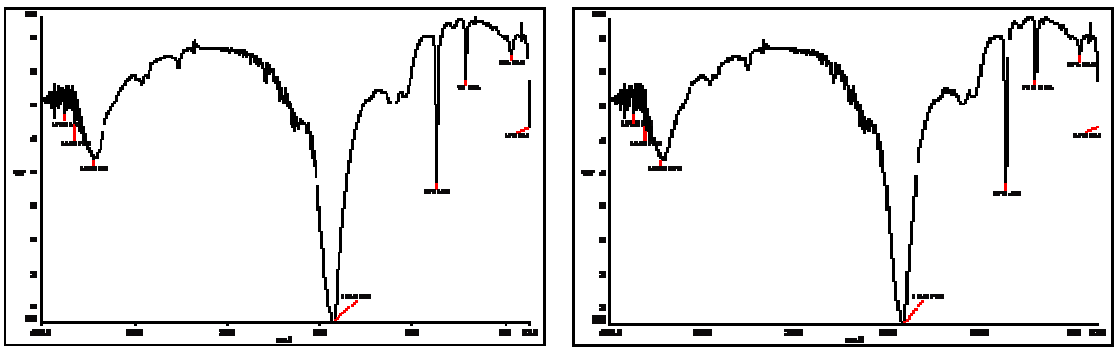

Figure (9) FTIR. spectra showing **a** bonding material of plaster (animal –glue) **b** color bonding material (animal –glue)

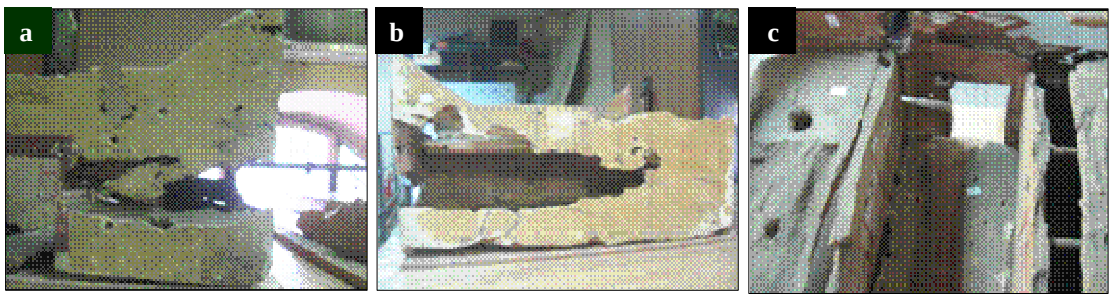

Figure (10- a, b, c) deterioration of wood (weakness in the bonding forces between fibers), and fungi infection.

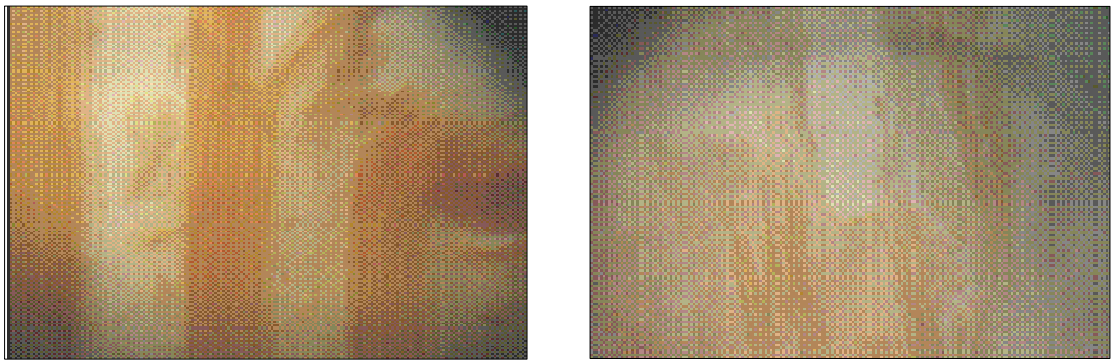

Figure (11) **a** light microscope photo of (L.S) section confirming weakness of wood **b** (R.L.S) section confirming weakness of wood

4. CONCLUSIONS

Based on the results of the aforementioned analyses, the type of wood is pinus nigra, which is considered to be a soft type of wood, and has more predisposition to biodegradation. The fungi (Chaetomium sp., Penicillium sp., Aspergillus flavus, and Bacillus Bacteria) were also detected on painted wood as a biodeterioration, due to severe dryness and weakness of the painted wood. Much of these deterioration appear as cracks, broken parts, fungi colonies, and loss of pigments in many parts. EDX analysis reveals the presence of (Ca-C-Na-P-S-Cl-K-Si- Al-C-Fe-O-) in plaster layer and pigments. Pigment materials in the grain store model are affected by salts and air pollution .Sodium chloride (halite)was detected in the analyzed samples. It plays an important role in the decay of Egyptian model .Atmospheric sulfur which was found on plaster and pigment samples is responsible for the darkening. The bad storing was responsible for the high percentage of dust which acts as an accelerating factor of wood damage and organic rest from animal glue which was a good medium of microbiology. XRD pattern reveals the presence of calcium carbonate $CaCO_3$ as a white pigment, and hematite Fe_2O_3 as a red pigment. FTIR analysis of the residues indicates that the bonding material is animal glue. The painted wooden model of grain store in the Egyptian museum is deteriorating due to the action of these compounds especially in the saturation and desiccation cycles .Dryness of animal glue and wood resulted in cracks and loss of many parts of wood and pigments .Bad storing ,organic rest and dust are good medium of microbiology.

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