ORIGINAL PAPER

ANALYTICAL INVESTIGATIONS ON A FIRED STUCCO WINDOW IN THE ISLAMIC ART MUSEUM STORE OF CAIRO, EGYPT

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Abstract. *The stucco window in this study is kept in the stores of the Museum of Islamic Art in Cairo, Egypt, and bears the number 454/7. This window has been exposed to many damage factors, the most important of which is the fire that broke out in the museum in 2006 AD, in addition to the effect of the water that was used to extinguish the fire. This research aims to study the components of the window (stucco - glass - wood) and identify the transformations resulting from the effect of fire using optical microscopy, scanning electron microscopy coupled with EDX, X-ray diffraction, and infrared spectroscopy. In addition, the microbiological damage resulting from the moisture that saturates the plaster and wood was investigated.*

Keywords: *Museum store; fired; stucco window; XRD; SEM-EDX.*

1. INTRODUCTION

Stucco material has been widely used throughout the centuries since Pharaonic times till now as cartonnage, stucco masks, molds [1-3]. However, stucco windows are considered one of the most important and prominent architectural elements in Islamic architecture, as artists used them to create a relationship between the aesthetic and functional value, being used to reduce the load on the walls while also serving as decorative units and light source. This study focuses on the effect of fire on stucco windows as a composite material. Stucco windows contain three different materials, including the decorative formation of plaster, stained glass with plaster, and the wooden frame that takes the form of windows. As a result of this structure, each part is affected by damage factors in a different way according to its properties and structure [4]. Although the stucco window, the subject of the current study, is preserved in the Museum of Islamic Art in Cairo, Egypt, No. 454/7, it is not dated, but when compared with stucco windows during Islamic times, it is likely that it dates back to one of the buildings of the Ottoman era (Fig. 1).This window is characterized by repeated stucco decoration on both sides, surrounded by a wooden frame with a width of 7 cm, and its dimensions are 174 cm in length and 81 cm in width, and it is decorated with pieces of colored glass (yellow - purple - transparent).

The fire had the worst effect on the components of the window, the subject of the study. It is at a temperature above 30°C and has moderate relative humidity (30-40%). Gypsum gradually loses bound water and turns into anhydrite [5-7]. The high temperature also helped to expand the iron inside in reinforcement of the plaster frame of the window [7, 8]. Consequently, its size increased, which led to cracking and breaking the plaster

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frame in the places of reinforcement. Cracking increases when the iron is exposed to high humidity (the water used to extinguish the fire) [9, 10]; where moisture helps to rust iron and increase its size as a result of the accumulation of iron oxides on its surface [11]. The rust compounds, also seep onto the surface of the stucco decoration through pores and cracks and deform them with hard-to-remove spots (Fig. 1c).

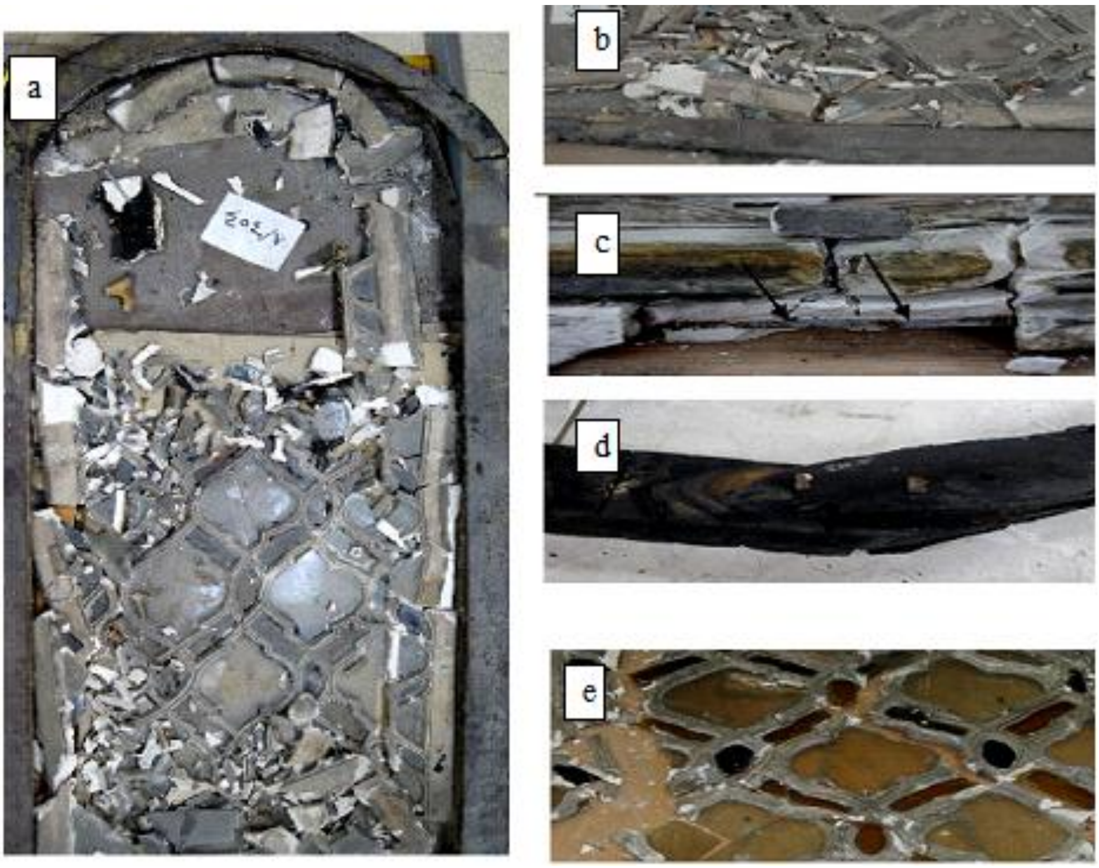

Figure. 1. The deterioration aspects of the stucco window number 454/7 in Cairo's Museum of Islamic Art

The fire also causes the spread of soot on the surface of the stucco decorations, and the gases resulting from the fire affect the stucco decorations, especially in the presence of moisture, which helps in the formation of acids deposited on the surface of the decoration, which leads to its damage [5, 12]. Moisture helps the growth of fungi on the surface of stucco decorations and deforms them and causes mechanical and chemical damages [9]; mechanical damage is the penetration of the fungal hyphae in the pores, causing many cracks and microcracks [13]. The chemical damage is represented in the acids secreted by these fungi, which cause severe damage to the stucco decoration.

The percentage of damage to the glass fillings because of the fire varies according to their proximity to it. The fillings directly close to the fire have cracked, as the increase in the temperature of the glass leads to the expansion and increase of the distance between the particles that make up the glass, and when water is used to extinguish it, a thermal shock occurs that leads to irregular cracking [8] (Fig. 1-a, e). In addition to the bad effect of high temperature on the glass, it was found that the effect of moisture is more harmful, especially if it is in the form of steam [14] where gases are deposited on the surface of the glass and turn into acids that attack the glass causing damage [15]. Moisture also causes the deposition of fine suspended particles on the surface of the glass, which leads to the growth of fungi [16]. The fire affected the wooden frame of the window, which led to the burning of part of the frame and its carbonization (Fig. 1-d). The rate of carbonization or charring varies according to the type of wood, its density, and the duration of exposure to fire [8], where the high temperature leads to dry and brittle wood [17]. Also, the use of water to extinguish the fire causes the pores of the wood to swell, which leads to a loss of strength [18]. The structural change of wood caused by severe drying and then moisture absorption causes severe deterioration of wood properties and irreparable damage [19].

This study highlights the importance of using the analytical methods in archaeological and restoration of ancient objects from cultural heritage [20]. In this respect, to identify the components and deterioration products of the stucco window, different analytical techniques were applied including optical microscopy (OM), scanning electron microscopy coupled with EDX (SEM-EDX), X-ray diffraction analysis, and Fourier transform infrared coupled with attenuated total reflectance (FTIR-ATR). These analytical techniques help to identify the conservation plan that will apply [3].

2. MATERIALS AND METHODS

2.1 SAMPLING

Twelve representative samples were carefully collected from areas of no aesthetic value, using a fine scalpel, to investigate the components of the stucco window and its deterioration (Table 1, Fig. 2).

Table 1. Coded samples collected from the stucco window, description and analytical method

Sample	Analytical method	Description
W1, W2	OM	Two samples to identify the type of wood.
OS1 OS2	XRD	Sample of the original stucco decoration away from the effect of fire to know its components.
CS1 CS2	XRD	Sample of the original stucco decoration exposed to fire to determine the signs of deterioration. Two samples of the completed stucco decorations To know their components and the manifestations of deterioration.
OSa	SEM-EDX	Sample of the original stucco decoration.
CSb		Sample of the completed stucco decorations.
YG	SEM-EDX	Sample of yellow glass to identify its components
PG		Sample of a purple glass to identify its components
TG		Sample of transparent glass to identify its components
CM	FTIR	Sample of the consolidation material used on the surface of the stucco decorations for identification

2.2. METHODS

The investigation of the wooden frame, where the cross and longitudinal sections were made to determine the type of wood, was performed by optical microscopy, using Leica Wild M690 microscope (Leica AG, Heerbrugg, Switzerland).

On the other hand, to investigate the material used for consolidation of the stucco decorations and examine the surface of the glass, National Optical DC4-456H Digital Stereo Microscope (National Optical & Scientific Instruments, Inc., China) with a magnification of 300× was used.

The identification of the minerals that make up the stucco decorations as well as clarification whether there was a previous restoration was made Axio Imager polarizing microscope (Carl Zeiss MicroImaging GmbH, Göttingen, Germany) connected to an AxioCam MRc5 camera and a Fujitsu Siemens computer monitor.

The morphological investigation and elemental content were performed by Scanning Electron Microscopy coupled with Energy Dispersive X-Ray Spectrometry (SEM-EDX) using a Philips XL30 ESEM scanning electron microscope system (Philips B.V., Eindhoven, Netherlands).

Figure 2. The places from where samples were collected for investigations

X-ray diffraction analysis of the stucco decorations was performed using a Philips PW 1840 X-ray diffractometer (Philips B.V., Netherlands) with CuKα1 (1.54056 Å) radiation at 40 mA and 40 kV. The scattered intensities were measured with a scintillation counter. The angular range (2) was from 5 to 45° with steps of 0.02°, and the measuring time was 0.5 s per step.

The qualitative analysis of the material used for consolidating the stucco decorations was performed by infrared spectroscopy using a FTIR 6100 Jasco spectrometer (Jasco, Japan). Finally, the fungal deterioration was studied to identify the fungi that infected the window because of the surrounding environment.

3. RESULTS AND DISCUSSION

3.1. OPTICAL MICROSCOPY

Microscopic investigation (Fig. 3) indicated that the wooden samples were identified as pine (*Pinus sp.*) asoftwood that grows in the Mediterranean region [21, 22]. The largest trees have a diameter of 50 cm and a height of 20 m [23]. Diagnostic characteristics have shown that the boundaries of the growth ring were distinct, thickwalled xylem and axial intercellular resin present with thin-walled epithelial cells in cross-section (TS). In addition, the longitudinal cross-section (TLS) showed mono-rays with medium height (5–15 cells) and radial intercellular resinous channels [24, 25].

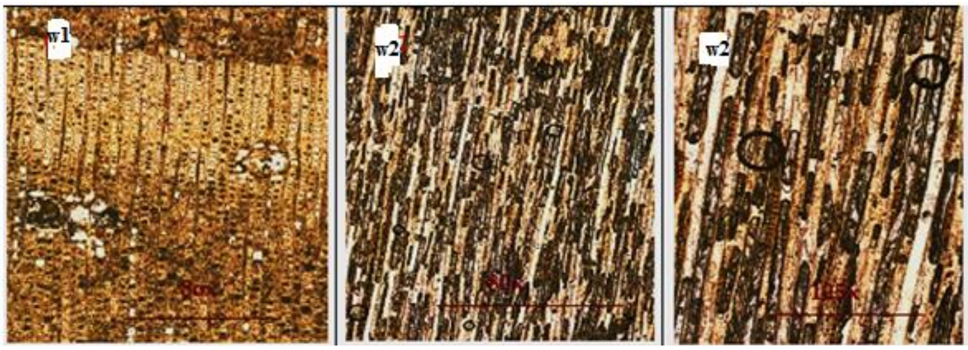

Figure. 3 Anatomical characteristics of samples taken from frame wood confirm that it is pine wood by optical microscopy; (w1) Transverse section; (w2)- Tangential section.

The consolidation material used previously in pasting the stucco decorations is deposited on the surface and do not penetrate the pores (Fig. 4). By examining the glass fillings to identify the signs of damage (Fig. 5), where images from Fig 5a, b represents the yellow glass fillings, is observed clear that there are several air bubbles.

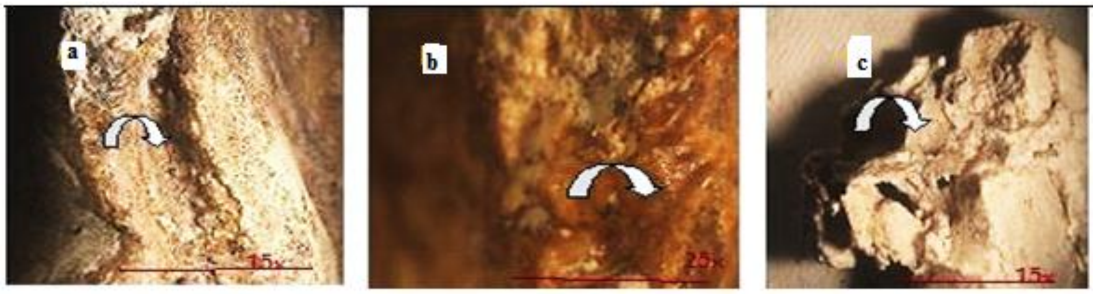

Figure. 4. (a, b) The application of the consolidation material on the surface of the stucco decoration, (c) the use of the same material to paste the damaged stucco pieces under a stereo microscope.

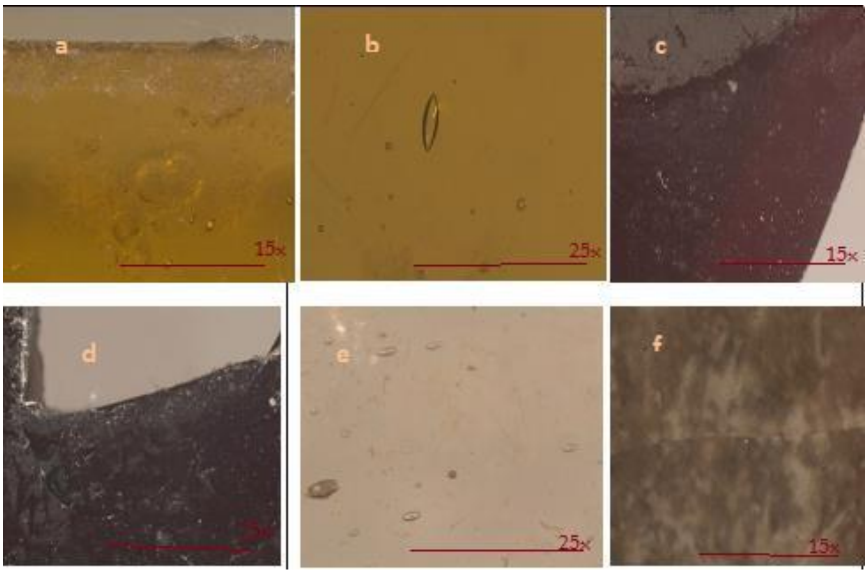

Figure 5. Stereomicroscopy examination (a, b) yellow fillings with air bubbles, (c, d) purple fillings with some broken and previously re-adhesive fillings, (e, f) translucent glass inserts.

The purple glass fillings show the deposition of soot and dust on the surface of the fillings due to the fire, as well as the adhesive material of the glass fillings with stucco decorations; in addition to the presence of a broken part in the sample (Fig. 5d) and re-adhesion (Fig. 5c, d). By investigating the transparent glass fillings, the spread of air bubbles can be seen through the samples (Fig. 5e, f), and this shows the deposition of soot on the surface, in addition to the presence of an impermeable fracture in the sample.

3.2. POLARIZED MICROSCOPY

The results of polarized microscopy, on a part of the original stucco that was exposed to fire, shown the presence of minerals from the gypsum, and the accumulation of soot on the surface of the stucco (Fig. 6a). The presence of anhydrite and gypsum crystals (Fig. 6b) is significant, confirming the exposure of the sample to different temperatures, which led to the gradual transformation of gypsum [8]. The examination reveals remnants of a previous restoration where calcite and quartz crystals appear (Fig. 6 c).

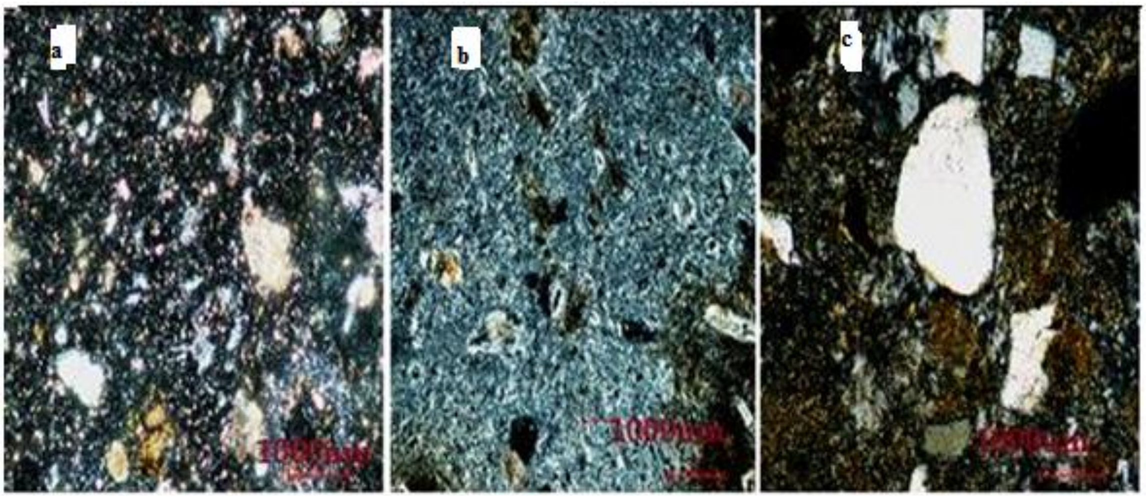

Figure 6. Microscopic examination of burnt stucco showing: (a) soot deposits on the surface of the sample; (b) the presence of anhydrite and gypsum crystals; (c) previous restoration with calcite and quartz crystals.

3.3. SCANNING ELECTRON MICROSCOPY

The results of the scanning electron microscopy investigation of stucco samples (Fig. 7a) from the original decoration of the window show an accumulation of soot on the plaster decorations and the disappearance of gypsum particles, as well as the transformation of gypsum into anhydrite. As a result of exposure to heat according to another study [7], it was observed gypsum crystals (Fig. 7b), which may mean one of two things: the sample was unaffected by the fire, or it was exposed to fire and a portion of the gypsum was converted to anhydrite, which was then transformed back into gypsum after exposure to moisture [26]. The images examination showed the use of components different from the components of the original stucco decoration, where large crystals of calcite appear in addition to the presence of quartz (Fig 7c).

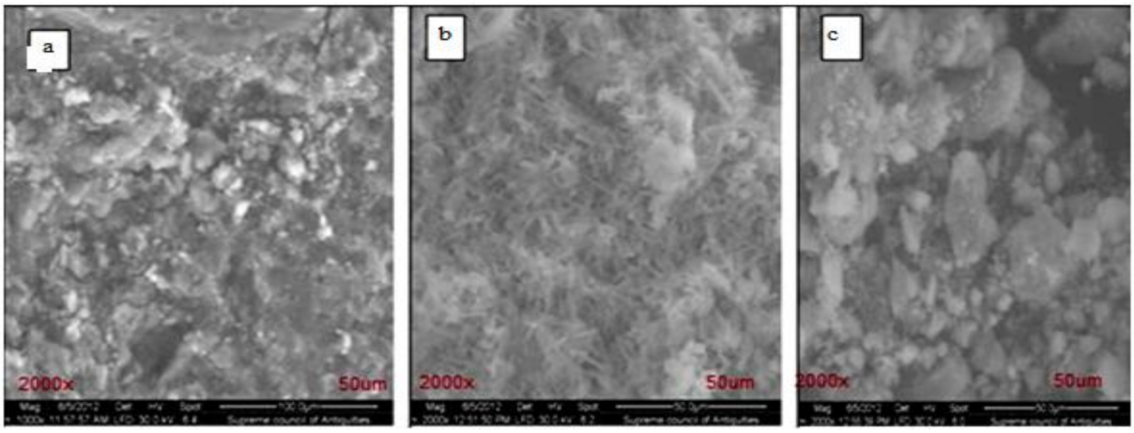

Figure 7. SEM micrograph (a) depicts the scattering of soot; (b) gypsum crystals; (c) calcite crystals and quartz.

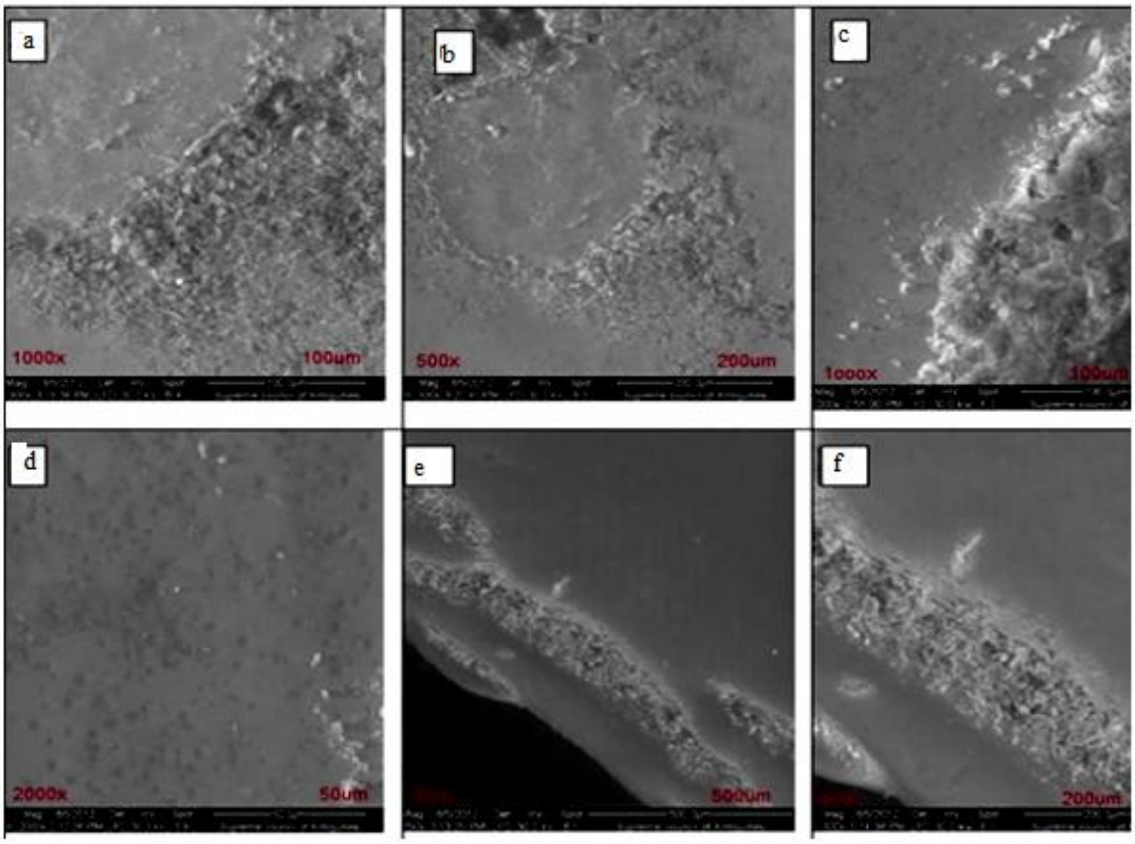

Figure 8. SEM micrograph for glass fillings shows; (a, b) erosion and weakening of the surface of the yellow fillings; (c, d) the stability of the purple fillings with some spots on the surface; (e, f) the stability of the the transparent fillings with some dust and dirt

The investigation of glass samples using the SEM technique, widely used in studying the surface appearance of antique glass, led to detecting have detected its corrosive surfaces and clarifying damage [27, 28]. Various samples were examined, and some glass fillings were represented. The results of the appeared examination are as follows (Fig. 8a-f): Fig. 8a-b represents yellow glass fillings with the accumulation of dust and dirt that appears on the surface, as well as erosion and weakness in the sample surface; Fig. 8c-d represents the purple glass fillings, showing the consistency and stability of these fillings, with spots on the sample surface; Fig. 8e-f the transparent fillings, the examination shows that the transparent glass is stable, but there is some dirt on the surface.

On the other hand, in order to investigate the timber frame samples and to verify the surface shape and characteristics of wood as well as to determine the type of wood used in the timber frame, the SEM technique was used [18]. Also, this method was used to examine the microscopic deterioration in the anatomical structure of wood [29]. The results of the investigation are presented in Fig. 9. The destruction and damage to the middle plate of the wood, which led to the separation of the woody cells from each other, as well as the collapse of the cell walls and their layers [25] it can see in Fig. 9a. On the other hand, the spread some cracks and cracks in the layers of the cell wall, the separation of the layers of the cell wall, and the destruction of adjacent holes [25], as well as the appeared cracks due to exposure to wetness and then dehydration at high temperatures [22] are highlighted in Fig. 9b. In addition, the appearance of fungal hyphae, which confirms the fungal infection due to exposure to high humidity is shown in Fig.9c [17].

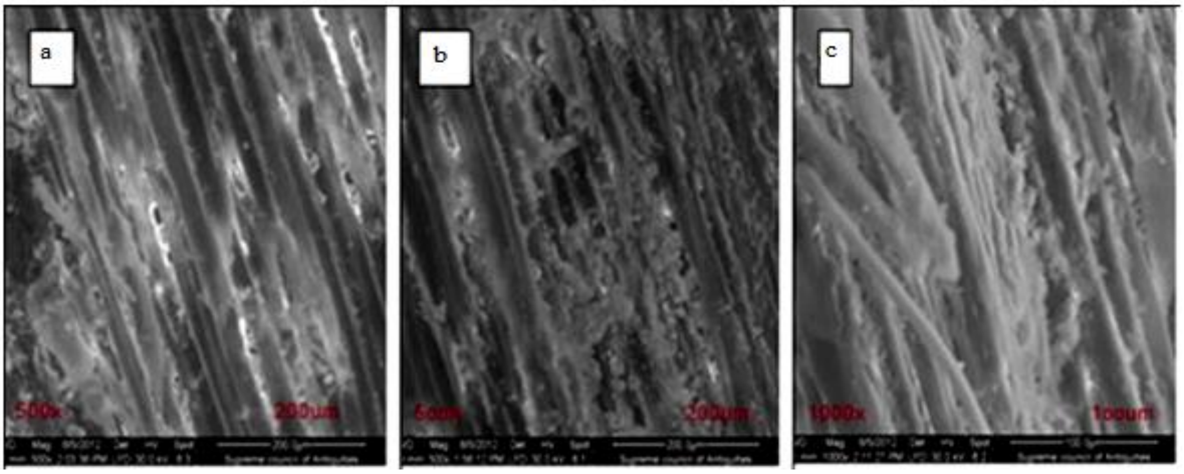

Figure 9. (a,b,c) SEM micrograph for wood frame Shows damage to wood cells as a result of exposure to high temperatures and moisture and the appearance of fungal hyphae in (c).

3.4. ENERGY DISPERSIVE X-RAY ANALYSIS

The results of EDX analysis of studied samples are presented in Table 2 and Figs. 10-11. Fig. 10 shows the presence of the following elements in the original stucco decoration of the window (*i.e.*, OSa): Ca, S, and O, which confirms that the main component is gypsum. In addition, for the sample of completion of stucco decoration (*i.e.*, CSb), it was confirmed the existence of an old previous restoration, and, in this regard, the following elements were proven Ca, S, O, C, Si and Fe. The presence of Ca, S and O elements confirms the presence of gypsum, while the presence of Ca, C and O highligth the presence of calcite. The presence of Si is evidence of the addition of sand when was made the restoring in the past. The element Fe also appeared as a result of the rust of the iron used in reinforcing the stucco frame of the window, as the exposure of iron to relative humidity (RH) and oxygen leads to the formation of iron oxides [11].

Regarding glass samples (Table 2, Fig. 11) is confirmed the presence of sodium (Na = 1.63%) and potassium (K = 5.92%), as main elements in the yellow glass (YG) sample. In addition to the low percentage of silica from its normal level, which represents (Si = 19.98%), as for calcium (the stable substance), it is suitable (Ca = 12.36%), and the presence of a high percentage of carbon (C = 30%), iron (Fe = 7.7%. The results proved the presence of magnesium (Mg), aluminum (Al), and sulfur (S) in small proportions, either as one of the additives that improve mixtures or as impurities [30].

Table 2. EDX data of the studied samples.

Percentage of elements [%]													
Sample	Kind of sample	C	O	Na	Mg	Al	Si	S	K	Ca	Fe	Cl	Mn
OSa	original stucco		34.44	-	-	-	-	21.68	0.90	42.98	-	-	-
CSb	completed Stucco	10.12	40.65	-	-	-	1.63	13.57	1.00	27.22	3.41	-	-
YG	yellow glass	30.17	19.57	1.63	1.05	1.05	19.92	0.61	5.92	12.16	7.71	0	0
TG	transparent glass	0	32.65	6.16	1.53	0	38.63	0	7.37	13.60	0	0	0
PG	purple glass	0	28.57	6.61	0	0	38.61	0	5.73	12.19	0	1.69	6.60

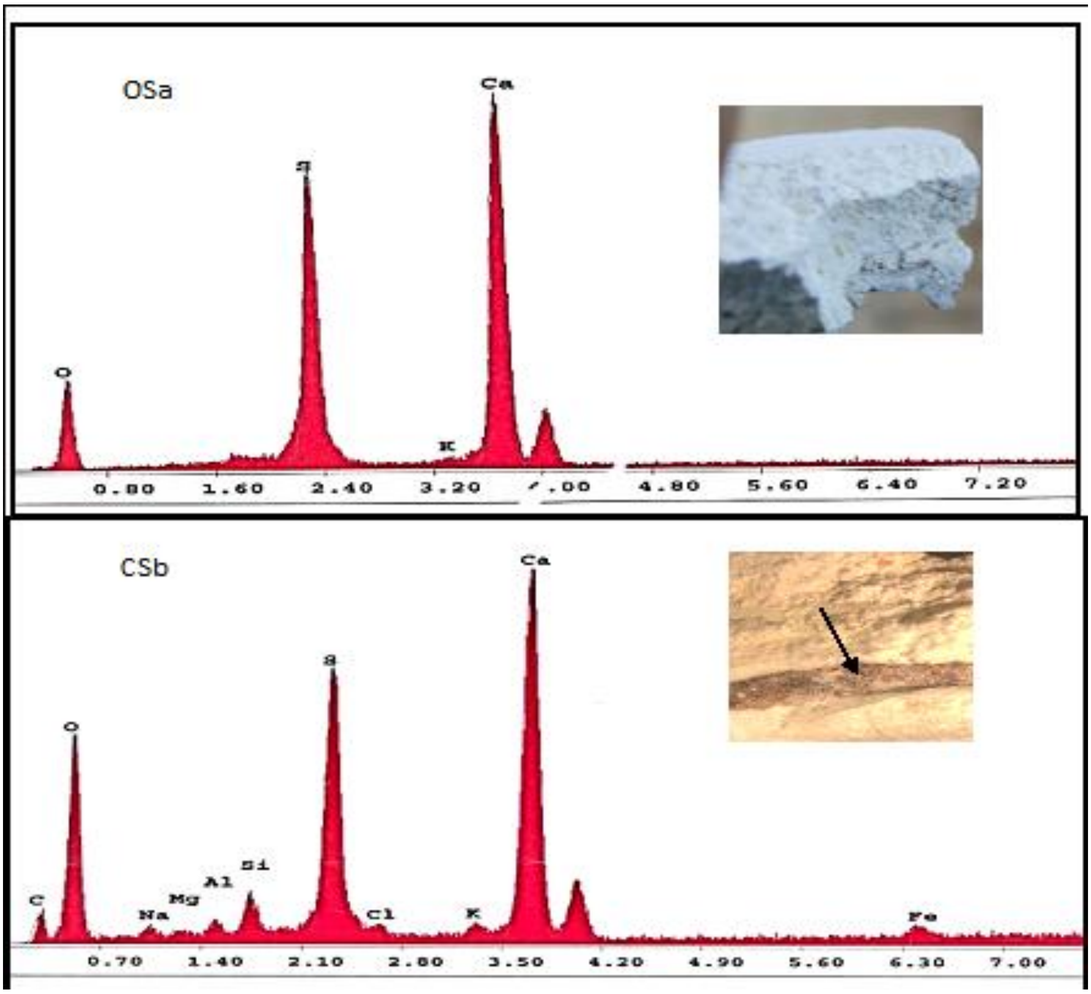

Figure10. EDX spectra of Stucco samples: (OSa) sample of the original stucco decoration and (CSb) sample of the completed stucco decoration.

The results of the EDX analysis of the transparent glass (TG) sample proved that the percentage of alkaline materials is typical, such as sodium (Na = 6.16%), potassium (K = 7.37%) and silica (Si = 38.63%). On the other hand, in addition to the presence of calcium (the fixing substance) (Ca = 13.66%), the results also showed a low percentage of magnesium (Mg), which is one of the improved materials in the glass industry, with no colored elements [30].

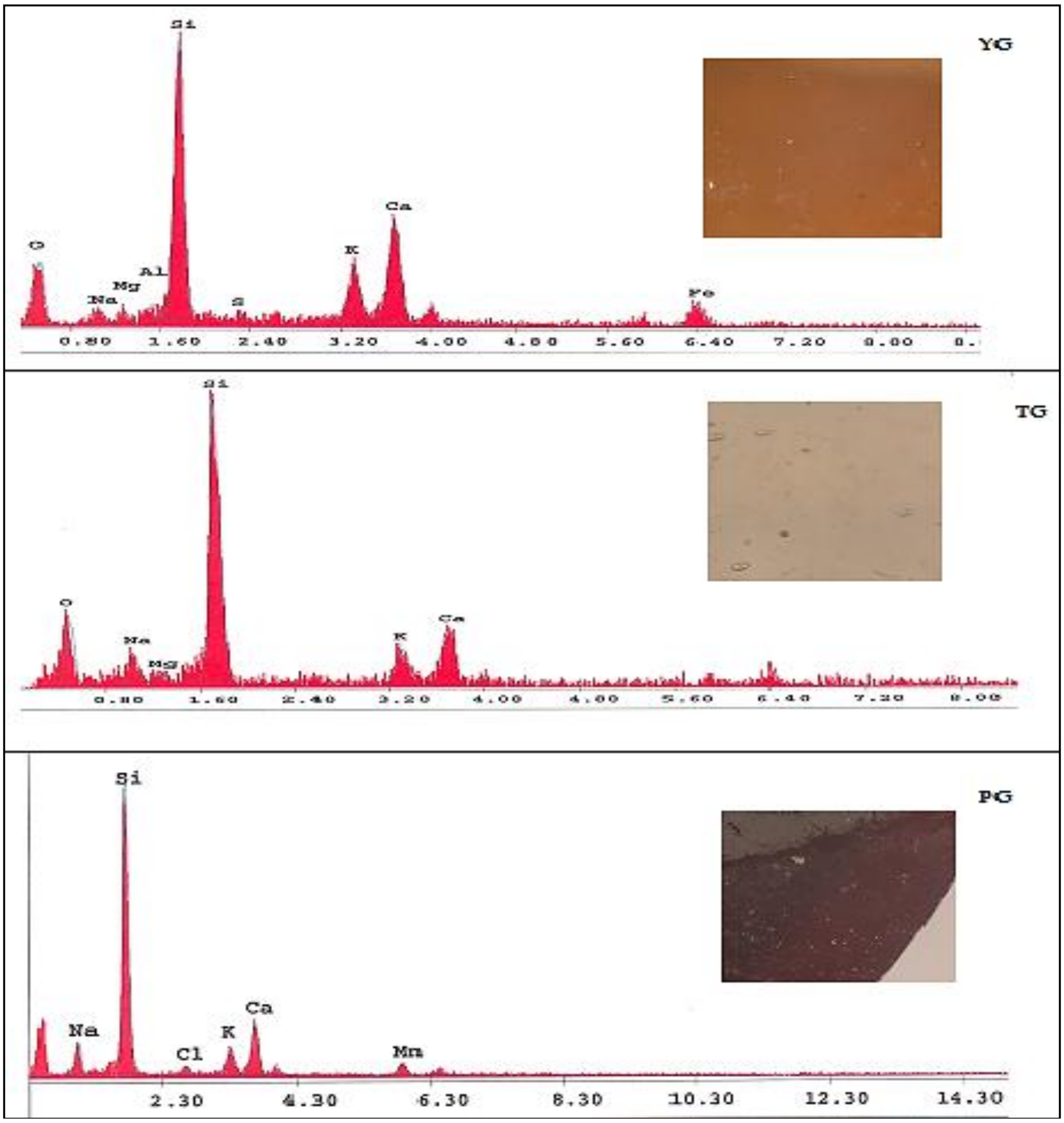

Figure 11. EDX spectra of Glass samples: (YG) a result of analyzing a yellow glass filler, (TG) a result of analyzing a transparent glass filler, and (PG) a result of analyzing a purple glass filler.

According to the purple glass sample (PG), the percentage of alkaline substances is as follows: sodium (Na = 6.61%) and potassium (K = 5.73%), which is a suitable percentage with the presence of calcium (the stabilizing substance) (Ca = 12.19%) in this ratio to make the glass more stable against deterioration factors and this confirms the stability of the purple glass and the presence of the silica ratio, which represents (Si = 38.61%). This means that the percentage of silica is typical, which increases the stability of the samples. As for the presence of manganese (Mn = 6.60%), it is responsible for the presence of the purple color [16, 31] and because of the high percentage of it, the purple color is darkened, as the presence of manganese in the sample in a ratio of (1.5:4%) gives the purple color, and as the ratio increases, the color darkens [28].

3.5. X-RAY DIFFRACTION

The results of the semi-quantitative XRD analysis of the mineral components of the stucco samples are presented in Figs. 12, 13, and Table 3. Fig 12 (OS1, OSof 2) shows the result of analysed samples of the original stucco decorations for the window. The results confirm that the main component of the original decorations is gypsum. Anhydrite also appears in the sample (OS2), and it is the result of exposure of gypsum to heat (fire). It can be concluded that a part of the gypsum is transformed to anhydrite, which weakened the decorations. [5,7]. Fig.13 (CS1 - CS2). shows the result of the analysis of the completed stucco decorations (previous restoration). The results confirm the existence of a false restoration, which is the use of a mortar that is different from the original mortar. The sample (CS1) consists of calcite (29.5%) and quartz (67%). The sample (CS2), consists of gypsum (65%), quartz (26%) with hematite (9%) as a result of the rust of iron used to reinforce the plaster frame of the window [11].

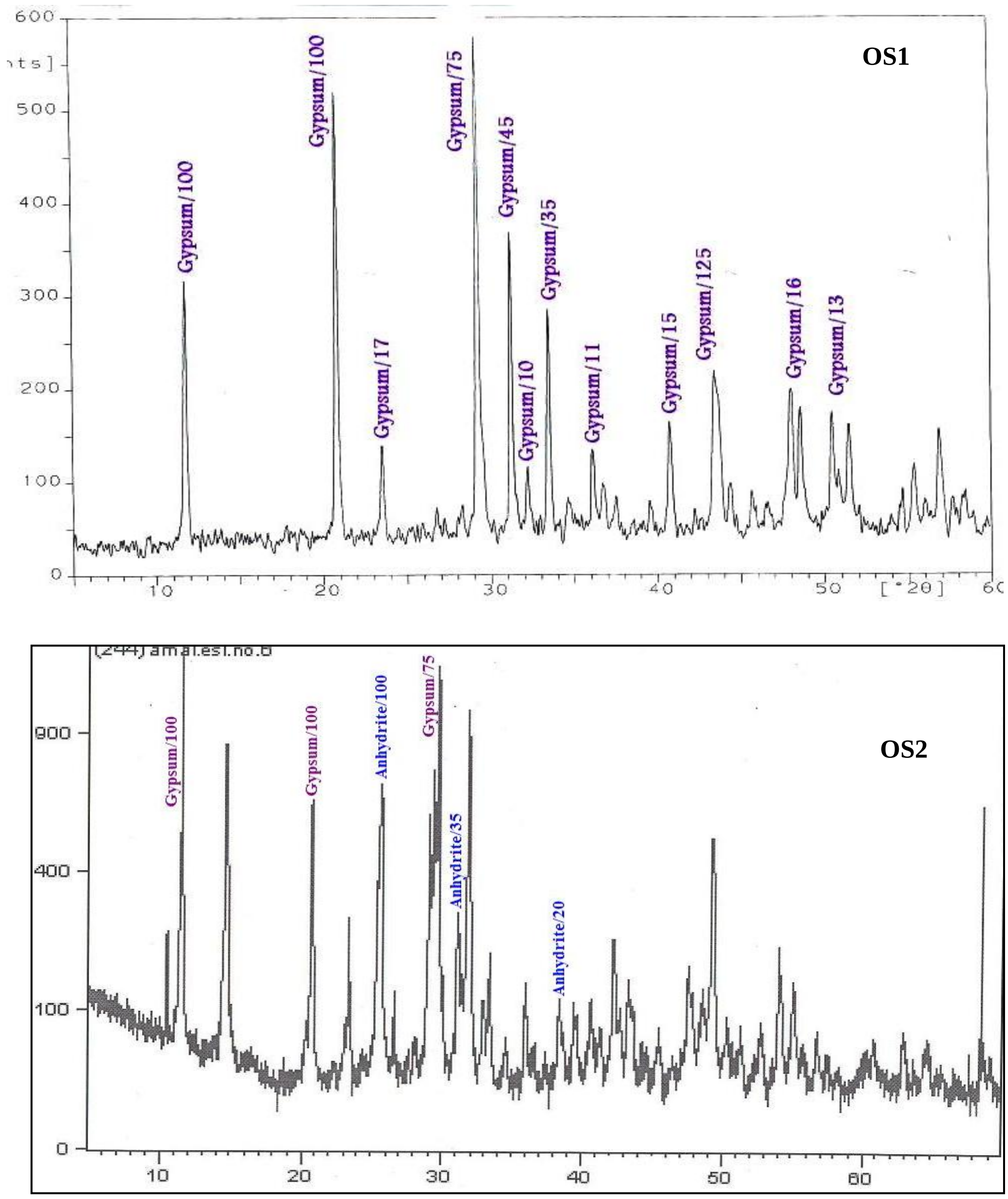

Figure 12. Samples (OS1-OS2) of the original stucco decoration which the major compound is gypsum.

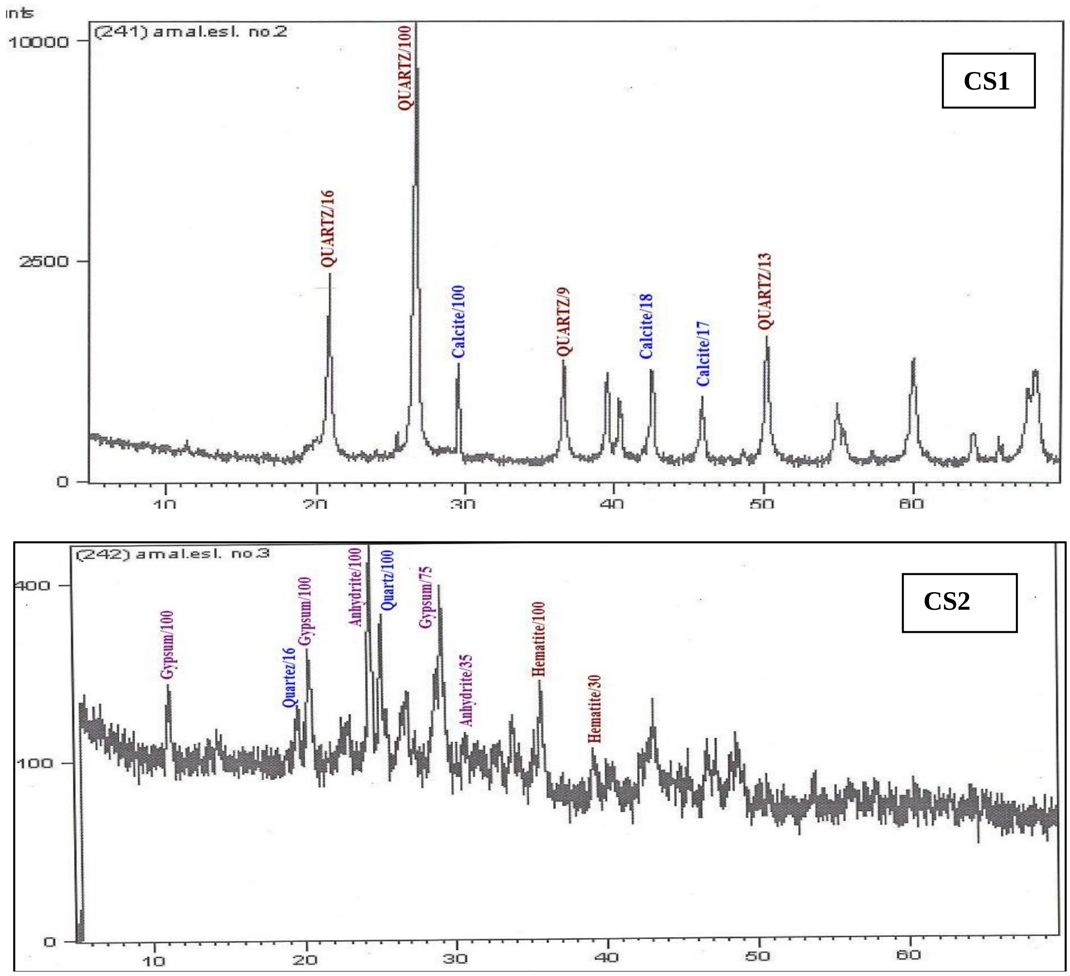

Figure 13. Sample (CS1-CS2) of the modern completed stucco decoration with new moderate with different compounds (calcite and quartz).

Table 3 X-Ray diffraction data

Compounds [%]	Card No	OS1	OS2	CS1	CS2
Gypsum	330311	100	55	-	35
Calcite	05-0586	-	-	29.5	-
Quartz	5-04490	-	-	67	26
Anhydrite	06-0226	-	45	-	30
Hematite	13-0534	-	-	-	9

3.6. FOURIER TRANSFORM INFRARED SPECTROSCOPY

The results of the analysis using FTIR proved that the material used to consolidate the stucco decorations is poly(vinylacetate), acronym PVAc. This was confirmed by comparison with a standard sample (Fig. 14, Table 4). The FTIR data represents a distinctive fingerprint for each substance separately [32-37]. The molecular vibrations characteristic of poly(vinylacetate) is concentrated mainly in the region of 500-1700 cm^{-1} [35-36], but a wide band in the region 3401 cm^{-1} is attributed to the same structure PVAc [36]. On the other hand, the functional groups [37] were attributed as follows: 3100-2800 cm^{-1} to the C-H stretching bands; 1750-1650 cm^{-1} to the C=O stretching band; 1480-1300 cm^{-1} to the C-H bending bands; 1300-900 cm^{-1} to the C-O stretching bands. Poly(vinylacetate) is one of the water-soluble polymers [38], which has been widely used in Egyptian museums to consolidating and adhesive artifacts.

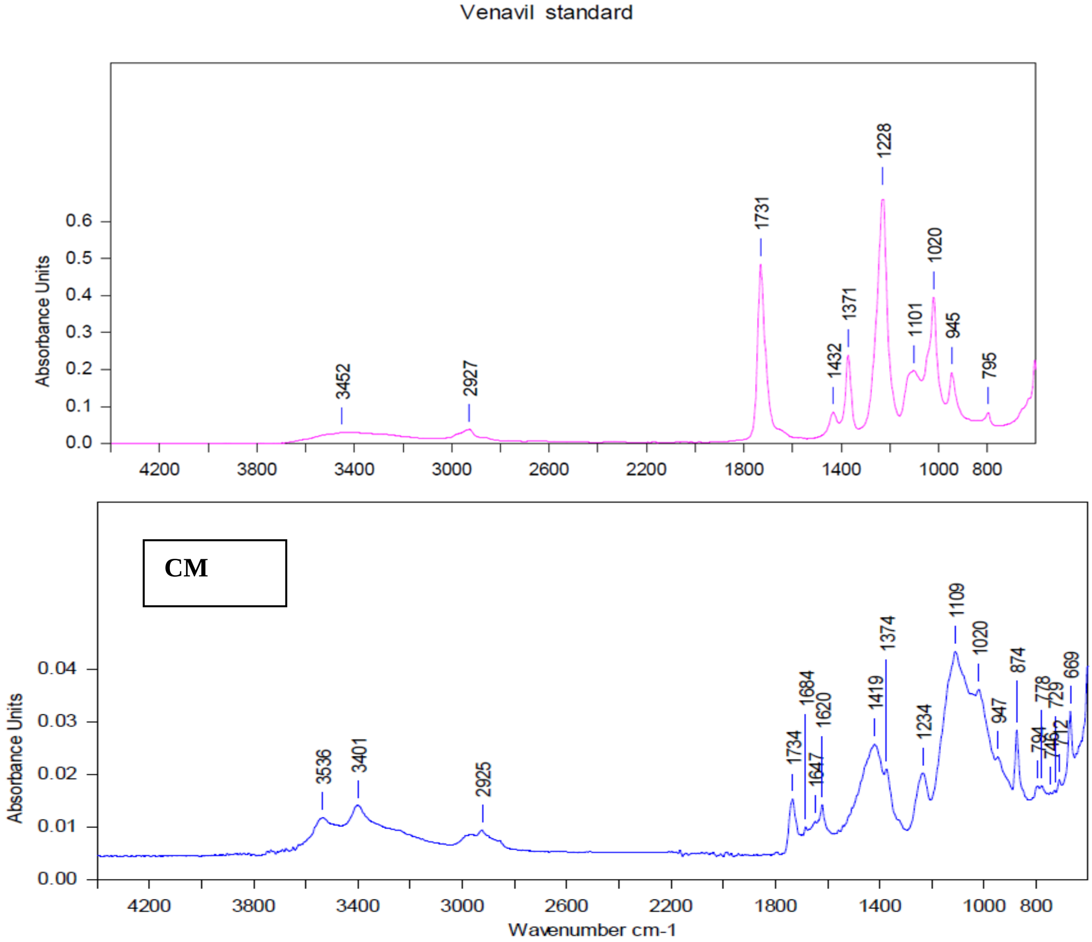

Figure 14. FTIR spectra of the standard of poly(vinylacetate) and the sample of the consolidation material (CM).

Table. 4 FTIR wavenumber and tentative assignments of functional groups for both PVAc standard and CM

Wavenumber of standard PVAc [cm^{-1}]	**Wavenumber of sample CM [cm^{-1}]**	**Tentative assignment**
3452	3401	OH- stretching
2927	2925	C-H stretching
1731	1734 1684 1647	carbonyl (C=O) stretching
1432 1371	1419 1374	C-H bending
1228 1101 1020	1234 1109 1020	C-O stretching

3.7. STUDY OF FUNGAL DETERIORATION

The environmental factors surrounding the window had a significant impact on the fungal growth, the most important of which was the temperature and humidity resulting from the use of water to extinguish the fire. The fungal growth on the all types of archeological object was influenced by some factors mainly being environmental factors such as humidity, temperature, pH, and not the last factor is the type of archeological object [39-42]. Fungal deterioration has been studied by collected the swabs from different places of the window (wood, glass, and plaster), using a sterile cotton bud. Then, the samples were placed in a fungus-growing PDA (Potato Dextrose Agar), which consisted of 200 g of potato extract, 20 g of dextrose, 20 g of agar, and the addition of a liter of distilled water, in Petri dishes [43-44]. The plates were incubated at 28 °C for 5-7 days. Then, the samples were examined in the Microbiology Laboratory and Research and Conservation Center of the Ministry of Tourism and Antiquities to diagnose the type of fungal infection.

Fungi have been identified according to various methods presented in different studies [45, 46]. The results showed (Fig. 15) that the fungal growths on the window including *Aspergillus flavus; Asp fumigatus; Asp Wentii; Asp Niger; Pen Chrysogenum; Pen Rubrum; Fusarium sp; Rhizopus sp; Aspergillus terrus; Aspergillus sp; Penicillium sp*. These results are in agreement with various studies in this field [47-50].

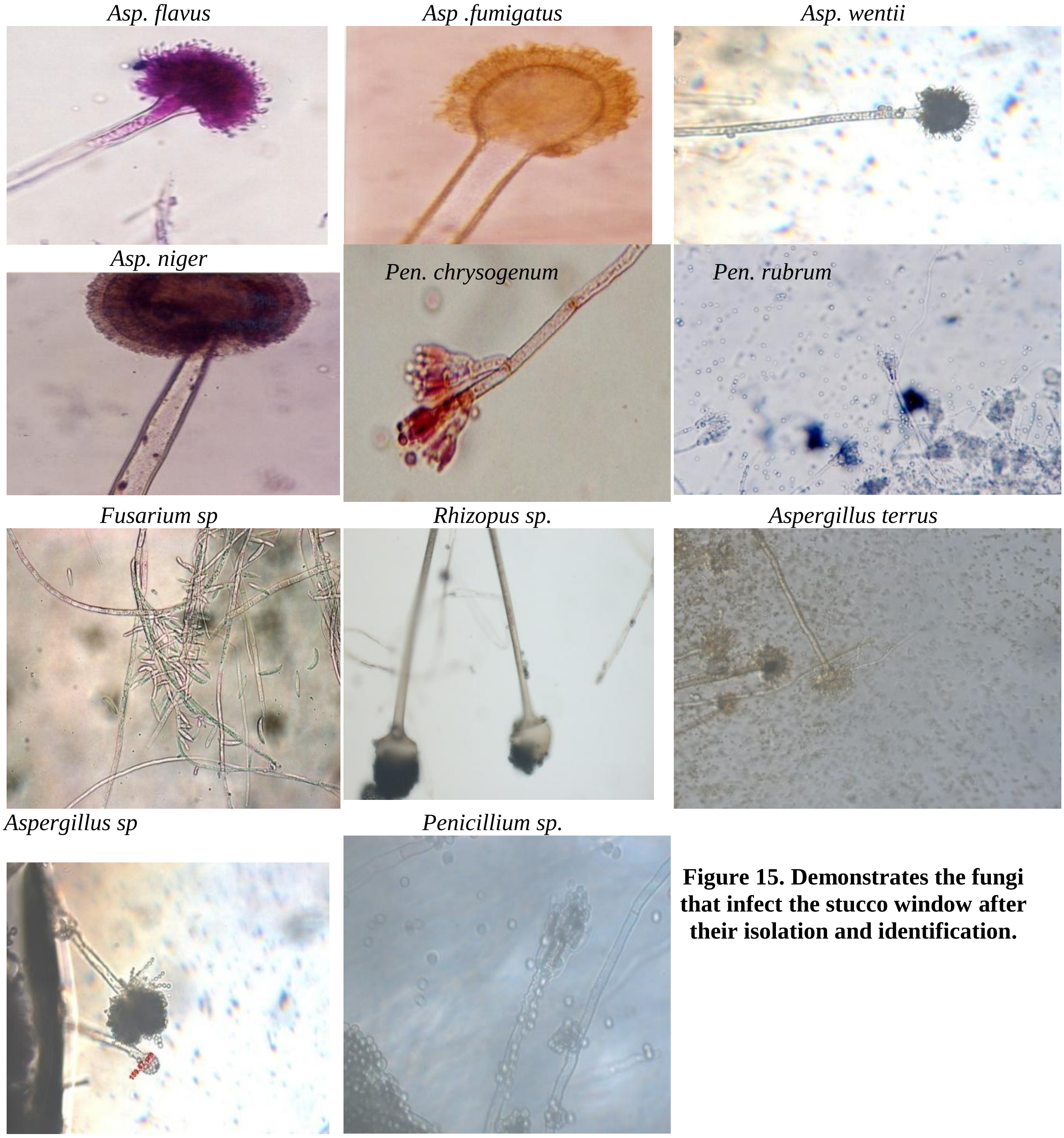

Figure 15. Demonstrates the fungi that infect the stucco window after their isolation and identification.

4. DISCUSSION

Fire is one of the damage factors that may result in the loss and destruction of antiquities completely [50]. The effect of the fire varies on the antiquities according to the proximity or distance from the source of the fire, as well as the type of antiquities and the intensity of the fire [51]. Regarding the effect of fire on the window under study, the visual examination proved the burning of an entire part of the wooden frame, the examination with the electron microscope showed us damage to the tissues and bronchioles of wood as a result of exposure to high temperature, and then high humidity. resulting from the use of water to extinguish the fire.

The visual examination proved the deposition of soot and dust on the surface of the stucco decorations as a result of the fire. The microscopic examination also showed the presence of a consolidation material on the surface of the stucco decorations, which was identified using FTIR, which confirmed that it is polyvinyl acetate. This is done by identifying the distinct functional groups of the material.

The analyzes and examinations also confirmed the transformation of a ratio of gypsum into anhydrite as a result of exposure to high temperature, which caused the weakness and fragility of the stucco decorations [5, 7]. It also proved the existence of a false restoration of the stucco decorations using a mortar that is different from the original mortar, which consisted of gypsum only. The visual examination proved the deposition of dust and soot on the surface of the glass fillings as a result of the fire. Examination using a stereo microscope of the yellow and transparent fillings showed the presence of air bubbles, which are formed as a result of the retention of gases inside the glass paste. These cause the porosity and weakness of the glass [27, 31, 52]. SEM technique also showed weakness and erosion of the yellow fillings, and this was confirmed by the EDX analysis, which confirmed the lack of sodium (Na = 1.63%) and potassium (K = 5.92%) in the yellow glass than the normal rate. This is due to the effect of moisture or condensation, which led to the migration of sodium to the surface and its loss. In addition to the solubility of silica, its percentage is lower than its normal level (Si = 19.98%), which confirms the effect of moisture [8, 15, 31].

The EDX analysis also showed the presence of iron (Fe = 7.71%) in the yellow fillings, which is due to the yellow color [16, 27, 30]. The SEM investigation also revealed the presence of spots on the surface of the purple fillings, which may be a fungal infection due to the deposition of dust on the surface of the glass and the high level of moisture. EDX analysis showed that the proportion of manganese (Mn = 6.60%) is responsible for the purple color [16, 30, 31].

According to the investigations, the glass is soda-lime-silica (Na_2O-CaO-SiO_2) the common type throughout the ages [53,54], and is highly resistant to corrosion mechanisms [55]. Finally, these conditions represent a good environment for the growth of the fungi that were isolated and identified according to various studies [44,45]. These selected fungi are *Aspergillus flavus, Asp fumigatus, Asp Wentii, Asp Niger, Pen Chrysogenum, Pen Rubrum, Fusarium sp, Rhizopus sp, Aspergillus terrus, Aspergillus sp, Penicillium sp.*, which may cause chemical and physical damage to the components of the window under study.

4. CONCLUSIONS

The results obtained by qualitative and quantitative techniques (EDX, XRD and FTIR) on the stucco window concluded the following: Part of the gypsum, the main and only component of the stucco window decorations, has turned into anhydrite as a result of the high temperature as a result of the fire in the museum, a previous restoration For some stucco decorative elements, using lime instead of gypsum with a percentage of sand, this was confirmed by the presence of calcite and quartz. The use of polyvinylacetate as a surface consolidation for stucco decoration has been proven. The glass used in window fillers is of the type of soda-lime-silica (Na_2O-CaO-SiO_2), which is the most prevalent throughout historical times as it has a high degree of stability and resistance to damage factors. The results of the examination also proved that the type of wood used in making the wooden frame for the window was pine (Pinus sp), as well as that it was at a high degree of damage as a result of exposure to fire. The high temperature, and then the use of water to put out the fire, caused the sudden expansion and contraction of the stucco, causing the stucco decorations to crack and crumble. The moisture affected and helped to rust the iron used in the connection between the stucco decorations and the wooden frame and helped create a good environment for the growth of fungi. The fire also had the same effect on the glass fillings, which led to the cracking of many of them, in addition to the deposition of soot and dust on all components of the stucco window, and parts of the wooden frame were burnt, and the rest of the frame was weakened and damaged.

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