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TECHNICAL PAPER

FUNGAL DETERIORATION OF HISTORICAL TEXTILES AND APPROACHES FOR THEIR CONTROL IN EGYPT

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This study represents both a study case about the fungal microflora deteriorating historical textiles in the Egyptian Museum and the Coptic Museum in Cairo, and evaluation of the efficacy of several combinations of consolidants for reinforcement of textiles and fungicides for prevention of fungal deterioration. Two different methods were used for isolation of fungi from historical textile objects. The plate method with a manual key was used for identification of fungi. The results show that the most dominant fungi isolated from the examined textile samples belong to *Alternaria*, *Aspergillus*, *Chaetomium*, *Penicillium* and *Trichoderma* species.

Microbiological testing was used for evaluation of the usefulness of consolidation polymers combined with fungicides in prevention of fungal deterioration of ancient Egyptian textiles. Textile samples were treated using four selected polymers combined with two selected fungicides. Untreated and treated textile samples were deteriorated by three selected active fungal strains isolated from ancient Egyptian textile objects. This study reports that all of the tested polymers combined with fungicides prevent fungal deterioration of textiles. The treatments not only reinforce textiles, but also prevent fungal deterioration and increase their durability. The tested polymers without fungicides reduce fungal deterioration of textiles but do not prevent it entirely.

1 Introduction

Fungal deterioration can lead to very fast deterioration of organic museum materials such as paper, textiles, wood, etc.[1-3] The ability of textiles to absorb and retain moisture from the surrounding environment in the museums, coupled with their organic components makes them highly susceptible to fungal deterioration. There are many factors causing historical textiles to be more liable to fungal deterioration, e.g. they are good nutrient sources. Progressive changes of

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properties of textile materials are common done during natural ageing and they may cause historical textiles to become more susceptible to fungal deterioration.[4]

Fungal deterioration of historical textiles is a serious conservation problem in Egypt.[3] This is due to improper environmental conditions promoting fungal growth and changes in the nature of the textiles. Due to the surrounding environment, historical textiles in Egypt are more acidic,[5] which makes the conditions for fungal growth more favourable. High humidity accompanied by a lack of ventilation in storage rooms in Egyptian museums also enhances fungal growth on textile objects. In some cases, contaminated conservation materials can cause fungal infestation of conserved textile objects.[6]

Fungal deterioration of textiles causes changes in the properties of textiles such as loss of strength, general durability, discolouration, and appearance. In addition, many fungi contain coloured substances that can cause stains and spots on textile objects.[7-8] These stains contain chemical substances which deteriorate a textile object even if the fungus is dead.[9-10] For this reason it is important task to remove fungal stains from textile objects. The chemical changes occurring during fungal growth result in decreased fabric strength and lead to partial or total destruction of the material.[4] Mould can be dangerous to people who work in museums and in some cases can pose major health hazards.[11]

There are different methods for prevention of fungal deterioration of textiles, using chemicals and non-chemical methods. Chemical treatments include using fungicides and fumigants. Non-chemical methods include the use of UV rays, gamma rays, heat, electron beams and microwaves.[1] Unfortunately, many of these methods have not been evaluated well from the conservation perspective. Most of the methods mentioned above may cause damage to ancient textiles such as fading of dyes, dryness of fibres, and decrease of strength of textile fibres.

It should be emphasized that the best method to prevent fungal growth on museum textiles is to protect textile surfaces from contamination, control moisture in materials, keep relative humidity low and avoid treatments which may activate germination.[6] Prevention of fungal deterioration by controlling the environment in storage rooms is very expensive, so that not all museums in developing countries such as Egypt can apply such methods.[13] In such situations, other solutions have to be devised, such as fumigants and fungicides for preservation of textiles. There are a large number of studies that have been carried out on fungicides used for protection of museum textiles.[13-14] A number of industrial studies have been carried out on microbial deterioration and degradation of polymers and on their protection with biocides.[15-17] Some studies have also been done for textile conservation purposes.[18-19] In this study a new approach for prevention of fungal growth on historical linen textiles in need of reinforcement using polymers was evaluated.

2 Experimental

2.1 Identification of fungi from textile samples

Various biodeteriorated textile samples were collected from storage rooms in the Egyptian Museum and the Coptic Museum in Cairo. All textile samples collected from the Egyptian Museum composed of linen fibres only, while the samples collected from the Coptic Museum were composed of linen and wool fibres. Both cotton swab technique and biodeteriorated textile part technique were used for isolation of fungi from historical textile objects.[20] In biodeteriorated textile part technique very small biodeteriorated fibres separated from the original ancient textile objects were washed with sterilized distilled water, transferred using sterilized tweezers and put on two modified media in Petri dishes.[3] The used media are (i) medium of Greathouse, Klemme and Barker with a disk of pure 100% linen fabric with linen textile samples or with disk of pure 100% wool fabric with wool textile samples,[3] (ii) Czapek-Dox agar modified without sugar with disk of pure 100% linen fabric with linen textile samples or with disk of pure 100% wool fabric with wool textile samples.[3] Although it wasuse of parts of the investigated objects is method for identification of fungi from biodeteriorated historical textiles,[3] this method is considered a destructive method and it cannot be used for investigated textile objects in this study. Instead, the cotton swab technique was applied.[20] In the cotton swab technique, the fungal species were isolated using sterile moist cotton buds swabbed over the surface of ancient textile objects where fungal growth or fungal structures were observed. Cotton swabs were then used to distribute fungi on the media in Petri dishes mentioned above. The dishes were incubated at 28 °C for 3-4 weeks (until growth of colonies was observed). For purification and identification of fungi, the developed fungi were isolated in pure culture on slants of the appropriate media (Czapek dox agar and malt extract agar).[21] Identification of fungal species was performed

according to standardized methods by consulting the appropriate manuals.[22-25]

2.2 Evaluation of consolidants for fungal control

It was confirmed in previous studies that some polymers used in conservation of historical textiles can accelerate fungal growth on historical textiles,[26] and that some polymers may inhibit the fungal growth.[18-19] This study introduces a new approach by adding selected fungicides commonly used in textile conservation to some selected polymers which are commonly used in textile conservation.

2.2.1 Consolidants and fungicides

Four selected polymers were used in this study (Table 1). The polymers were selected according to relevant literature confirming that these polymers are suitable, effective and commonly used for reinforcement of textile artefacts.[19,27]

	Trade name	Chemical name	Producer
1	Klucel G (SD)	Hydroxypropylcellulose	Lascaux Restauro
2	Lascaux 498 HV (E)	Butyl acrylate / methyl methylacrylate	Lascaux Restauro
3	Mowilith DM5 (E)	Vinyl acetate / acrylic ester copolymer	Hoechst
4	Mowilith DMC2 (E)	Vinyl acetate / dibutyl maleate copolymer	Hoechst
5	Tylose MH300 (SD)	Methyl hydroxyethyl cellulose	Hoechst

Table 1: Consolidants used in the study.

The fungicides (Table 2) were selected according to the relevant references demonstrating their positive effect against fungal deterioration of textile artefacts.[28]

Trade name	Chemical name	Producer
Preventol O-Na	Sodium *o*-phenyl-phenol (NaOPP) / 2-hydroxybiphenyl sodium salt tetrahydrate	Bayer
Neo-Desogen	Aqueous solution of ammonia with a strong biocidic action	ARTE

Table 2: Fungicides used in the study.

2.2.2 Preparation of samples

Unbleached Egyptian linen fabric was used in this work and its specifications are shown in Table 3. The fabric was cut into 10 × 2 cm (length × width) test specimens. The warp strips were produced by ravelling away yarns on each side forming 1.5 cm wide strips with a 2.5 mm fringe down each side. Five samples were used for each test.

Structure	Thread (cm)		Liner density (Tex)		F max (%)	Tensile strength (N/mm²)
Plain weave	warp	weft	warp	weft		
1/1	20	20	20	20	18	34.35

Table 3: Specifications of the linen used in the study.

2.2.3 Treatments

The samples were treated with the selected polymers by impregnation,[19] with some modification in the technique by adding the tested fungicides to the solution. The Preventol was used in 1% concentration and Neo-Desogen was used in 2% concentration (Table 4).

Denotation	Treatment
0	Blank (untreated) samples
1	Klucel G 4%
2	Klucel G 4% + Neo-Desogen
3	Klucel G 4% + Preventol
4	Lascaux 498 HV 10%
5	Lascaux 498 HV 10% + Neo-Desogen
6	Lascaux 498 HV 10% + Preventol
7	Mowilith 10%
8	Mowilith 10% + Neo-Desogen
9	Mowilith 10% + Preventol
10	Tylose 4%
11	Tylose 4% + Neo-Desogen
12	Tylose 4% + Preventol

Table 4: Denotation of samples in this study.

2.2.4 Fungal deterioration

Treated and untreated linen textile samples were exposed to degradation by pure culture of *Aspergillus niger, Chaetomium golobosum and Penicillium funiculosum* by using Agar plate test. These fungal species are the most dominant fungal species isolated from ancient Egyptian textiles textile samples in this study. It was confirmed in previous studies that the selected three fungi have the greatest role in the decomposition of cellulosic materials.[29-30] These fungi are commonly used for evaluations of resistance of polymers against fungal deterioration.[14] Petri dishes on the Czapek-Dox agar medium modified without sugar was used.[3] The medium was inoculated with spore suspension (14-day old culture) of each tested fungus. Spore suspension of the fungus was spread on the surface of medium. The textile samples were put on the inoculated surface of the medium. The plates were incubated at 28 °C. After 14 days, the linen samples were picked out and washed

with water to remove mycelium, then they were sterilized using alcohol and dried at room conditions.[18] Before testing, the specimens were conditioned at 20±2 °C and 65±2% RH.

2.2.5 Tensile strength and elongation

Tensile strength and elongation of all samples before and after the fungal treatment were tested using the testing instrument Zwick 1445. The tests were done according to ASTM (2000) D 5035-95.[31] The initial distance of jaws was 50 mm and the testing speed was 25 mm/min, temperature was 23 °C, and RH 65%. Five samples were used for each test and statistical data were calculated for all tested samples.

2.2.6 Colourimetry

The colour coordinates of all textile samples before and after deterioration by different fungi were determined using an Optimach 3100 colour Spectrophotometer and the CIELab colour system, in the Textile Conservation Laboratory, National Institute of Standards NIS, Egypt. The CIELab colour coordinates L (lightness), a (red/green axis), and b (yellow/blue axis) were recorded. The colour changes for all samples after the fungal treatment were calculated and expressed as ΔL, Δa, Δb. Calculation of the total colour change (ΔE) was done using the following equation:[19]

$$\Delta E = [(\Delta L)^2 + (\Delta a)^2 + (\Delta b)^2]^{0.5}$$

3 Results and Discussion

Fungi isolated from various biodeteriorated textile fabrics from storage areas in both the Egyptian Museum and the Coptic Museum, are shown in Table 5. The obtained results show that 204 isolates, representing 30 species of fungi were identified on samples obtained from the Egyptian Museum. The most dominant fungi on textile fabrics are *Aspergillus* (14 species), *Penicillium* (10 species), *Chaetomium* (4 species), *Alternaria* (1 species), and *Trichoderma* (1 species). It is noticed that the order of occurrence fungi on these textile fabrics is as follows: *Aspergillus* > *Penicillium* > *Chaeto-mium* > *Alternaria* > *Trichoderma viride*.

The obtained results show that 257 isolates, representing 36 species of fungi were identified on linen textile samples obtained from the Coptic Museum. The most dominant fungi on linen textile fabrics from are *Aspergillus* (17 species), *Penicillium* (12 species), *Chaetomium* (4 species), *Alternaria* (2 species), and *Trichoderma* (1 species). It is noticed that the order of occurrence fungi on linen textile fabrics from is as follows: *Aspergillus* > *Penicillium* > *Chaetomium* > *Alternaria* > *Trichoderma viride*.

The obtained results show that 77 isolates, representing 22 species of fungi were identified on wool textile samples obtained from the Coptic Museum. The most dominant fungi on wool textile fabrics are *Aspergillus* (12 species), *Penicillium* (8 species), *Alternaria* (1 species), and *Chaetomium* (1 species). It is noticed that the order of occurrence fungi on wool textile fabrics is as follows: *Aspergillus* > *Penicillium* > *Chaetomium* > *Alternaria*.

The results show that about 36 fungal species were isolated and identified on linen textiles from both investigated museums. The results in this study confirm that the occurrence of fungi on textile samples studied in the current study is more frequent than in the previous study by Abdel-Kareem et al.[3] It is noticed that 6 more fungal species were isolated in the current study than in the previous study. This may be due to the fact that the investigated samples in this study were collected from storage rooms while the investigated samples in the previous study were collected from display showcases and excavations. This result indicates that the textiles in storage rooms in the Egyptian museums are more exposed to the fungal deterioration problem than the textile collections in display areas. Also, the results show that linen textiles are more infested by fungi than wool textiles as the number of identified fungi on linen textile samples is higher than on woolen samples.

From the number of isolated fungi it is clear that textile collections suffer from excessive fungal infestation. This is due to that improper storage in both the Coptic Museum and the Egyptian Museum. The results show that the textile collection in the storage room in the Coptic Museum is more infested by fungi than in the Egyptian Museum. This may be due to the fact that most of the textiles in the Coptic Museum were collected from churches or tombs in worse conditions than in ancient Egyptian tombs. However the results show that the linen textile fabrics from the Coptic Museum are more liable to fungal deterioration than wool textile fabrics. These results are in agreement with the results obtained by Abdel-Kareem et al. who confirmed that all types of ancient textile fibres are liable to fungal attack; cellulosic fibres such as linen are more liable to fungal attack than animal fibres such as wool.[3]

	Fungus	The Egyptian Museum (linen)	The Coptic Museum	
			Linen	Wool
1	*Alternaria alternata* (Fr.) Keissler	8	11	5
2	*Alternaria tenuissima* Kunze	0	2	0
3	*Aspergillus carbonarius* Bainier	6	9	0
4	*Aspergillus auratus* Warcup	0	2	0
5	*Aspergillus cervinus* Neill	0	0	3
6	*Aspergillus chrysellus* Kown & Fennell	3	5	0
7	*Aspergillus fischeri* Wehmer	2	4	3
8	*Aspergillus flaschentraegeri* Stolk	2	4	0
9	*Aspergillus flavus* Link	12	14	4
10	*Aspergillus fumigatus* Fresenius	15	17	8
11	*Aspergillus nidulans* Eidam	9	11	3
12	*Aspergillus niger* Van Tieghem	13	14	7
13	*Aspergillus proliferans* Smith	0	3	0
14	*Aspergillus raperi* Stolk	0	0	2
15	*Aspergillus sparsus* Raper & Thom	0	0	2
16	*Aspergillus spinulosus* Warcup	0	3	5
17	*Aspergillus terrus* Thom	11	12	0
18	*Aspergillus ustus* Thom & Church	2	4	0
19	*Aspergillus versicolor* (vuill.) Tiraboschi	4	5	0
20	*Aspergillus wentii* Wehmer	0	0	2
21	*Aspergillus sp.*1	5	4	2
22	*Aspergillus sp.*2	4	4	2
23	*Aspergillus sp.*3	4	4	0
24	*Chaetomium cochlioides* Palliser	11	12	0
25	*Chaetomium globosum* Kunze	14	13	4
26	*Chaetomium sp.*1	7	6	0
27	*Chaetomium sp.*2	6	7	0
28	*Penicillium asperum* (Shear) n.comb.	6	8	0
29	*Penicillium biforme* Thom	0	2	0
30	*Penicillium canescens* Sopp	0	0	2
31	*Penicillium chrysogenum* Thom	4	10	0
32	*Penicillium citrinum* Thom	8	9	0
33	*Penicillium cyclopium* Westling	6	8	2
34	*Penicillium funiculosum* Thom	10	12	0
35	*Penicillium granulatum* Bainier	0	0	3
36	*Penicillium lanoso viride* Thom	0	0	2
37	*Penicillium paxilli* Bainier	0	0	6
38	*Penicillium raistrickii* Smith	0	2	0
39	*Penicillium soppi* Zaleski	6	5	6
40	*Penicillium wortmanni* Klöcker	7	9	0
41	*Penicillium sp.*1	4	6	2
42	*Penicillium sp.*2	4	5	2
43	*Penicillium sp.*3	4	3	0
44	*Trichoderma viride* Pers. Ex Fr.	7	8	0
	Total of isolates	204	257	77

Table 5: Frequency of fungal occurrence on the tested biodeteriorated textile samples.

The results show that most of the identified fungi belong to *Deuteromycetes*, i.e. imperfect fungi. These fungi are called conidial fungi because their growth is initiated by conidia.[10] They are capable of rapid growth when environmental conditions are favourable and are also able to survive under unfavourable conditions.[32] Most identified fungal species were reported in previous studies to cause deterioration of textiles. Many authors consider that many of these fungal species are among the most active fungi in view of degradation of historical textiles.[1-3,9,30] It was reported in previous studies that most of the identified fungi contribute to discolouration of textiles.[8,12,29] The results show that the most dominant fungi on the investigated textile samples belong to *Aspergillus* and *Penicillium*. These two genera are very important, since they include species that can grow at relatively lower moisture availability than other cellulolytic fungi. Under poor storage conditions, the water that such less demanding species produce as a result of their metabolism can accumulate, increasing moisture in materials to levels at which more highly deteriorative species may flourish.[4]

3.1 Evaluation of consolidants

Evaluation of the selected polymers combined with fungicides was carried out based on changes of tensile strength and colour of (i) unconsolidated, (ii) consolidated with polymers only and (iii) consolidated with polymers combined with fungicides, linen textile samples after the fungal deterioration.

3.1.1 Tensile strength and elongation

The results of tensile strength and elongation of all tested linen textile samples (unconsolidated, consolidated with polymers only and consolidated with

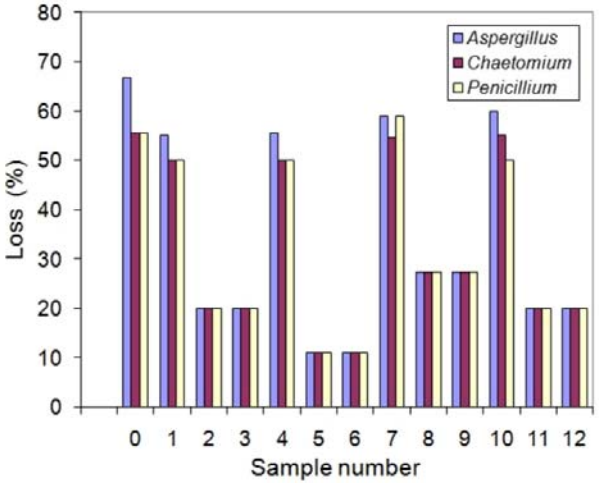

Figure 1: Loss of tensile strength of samples after fungal deterioration.

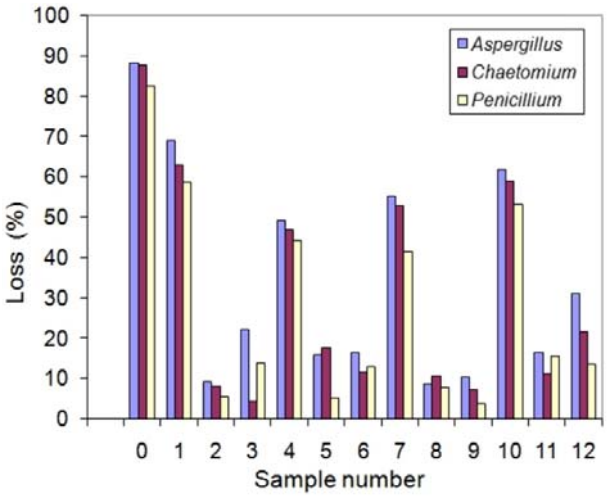

Figure 2: Loss of elongation of samples after fungal deterioration.

polymers combined with fungicides) after deterioration by all tested fungi are presented in Figures 1 and 2. The results show that there are considerable losses in the tensile strength and elongation of unconsolidated linen samples and linen samples consolidated with polymers without fungicides after the deterioration by all tested fungi. However the results show that the %loss of tensile strength and elongation of linen samples consolidated with polymers without fungicides are less than the loss of unconsolidated linen samples. These results confirm that the tested polymers without fungicides reduce fungal deterioration of linen samples but do not prevent the fungal deterioration completely. These results are in agreement with previous results obtained by Abdel-Kareem.[18] The results show that there are no considerable losses in the tensile strength and the elongation of all tested linen textile samples consolidated with polymers combined with fungicides after the deterioration by all tested fungi and that all tested polymers combined with fungicides prevent the fungal deterioration of linen samples completely.

Samples	Colour values						Colour change			
	Before			After						
	L	a	b	L	a	b	ΔL	Δa	Δb	ΔE
0	56.62	1.57	10.23	32.05	2.53	13.15	-24.57	0.96	2.92	24.76
1	53.57	2.01	10.48	47.75	2.57	11.26	-5.82	0.56	0.78	5.90
2	55.3	1.55	10.85	56.07	1.92	10.41	0.77	0.37	-0.44	0.96
3	57.23	1.68	11.42	55.37	1.93	11.13	-1.86	0.25	-0.29	1.90
4	55.65	2.52	11.33	46.53	2.33	11.02	-9.12	-0.19	-0.31	9.13
5	56.8	1.82	10.63	55.56	1.87	10.69	-1.24	0.05	0.06	1.24
6	57.46	1.76	11.23	56.71	1.98	10.68	-0.75	0.22	-0.55	0.96
7	54.26	1.74	10.48	44.42	2.14	9.48	-9.84	0.4	-1	9.90
8	56.67	1.75	11.14	54.61	2.69	11.97	-2.06	0.94	0.83	2.41
9	56.99	1.63	10.95	54.97	2.28	11.11	-2.02	0.65	0.16	2.13
10	54.64	1.76	10.77	44.26	2.31	9.73	-10.38	0.55	-1.04	10.45
11	56.46	1.67	11.31	54.77	2.11	10.53	-1.69	0.44	-0.78	1.91
12	56.74	1.85	10.8	55.46	2.36	11.17	-1.28	0.51	0.37	1.43

Table 6: Colour changes of samples after the fungal treatment with Aspergillus.

3.1.2 Colourimetry

Colour values and changes in colour of all tested linen textile samples after deterioration by the tested fungi are presented in Tables 6-8. Colourimetric measurements show that there are considerable differences in colour values of both unconsolidated linen samples and consolidated linen samples treated with polymers without fungicides after deterioration by the tested fungi. But the changes in colour of samples consolidated

Samples	Colour values						Colour change			
	Before			After						
	L	a	b	L	a	b	ΔL	Δa	Δb	ΔE
0	56.62	1.57	10.23	30.23	3.08	13.36	-26.39	1.51	3.13	26.62
1	53.57	2.01	10.48	48.22	2.13	11.08	-5.35	0.12	0.6	5.38
2	55.3	1.55	10.85	54.75	2.25	10.89	-0.55	0.7	0.04	0.89
3	57.23	1.68	11.42	55.42	2.31	11.04	-1.81	0.63	-0.38	1.95
4	55.65	2.52	11.33	46.26	2.71	15.58	-9.39	0.19	4.25	10.31
5	56.8	1.82	10.63	55.16	1.94	11.25	-1.64	0.12	0.62	1.76
6	57.46	1.76	11.23	56.05	2.36	10.97	-1.41	0.6	-0.26	1.55
7	54.26	1.74	10.48	48.9	2.92	13.67	-5.36	1.18	3.19	6.35
8	56.67	1.75	11.14	55.65	2.25	11.33	-1.02	0.5	0.19	1.15
9	56.99	1.63	10.95	55.5	2.27	11.14	-1.49	0.64	0.19	1.63
10	54.64	1.76	10.77	46.67	2.3	12.12	-7.97	0.54	1.35	8.10
11	56.46	1.67	11.31	56.17	2.02	10.79	-0.29	0.35	-0.52	0.69
12	56.74	1.85	10.8	54.93	2.32	10.27	-1.81	0.47	-0.53	1.94

Table 7: Colour changes of samples after the fungal treatment with Chaetomium.

Samples	Colour values						Colour change			
	Before			After						
	L	a	b	L	a	b	ΔL	Δa	Δb	ΔE
0	56.62	1.57	10.23	34.05	2.79	12.71	-22.57	1.22	2.48	22.74
1	53.57	2.01	10.48	48.5	2.06	15.19	-5.07	0.05	4.71	6.92
2	55.3	1.55	10.85	55	1.92	11.04	-0.3	0.37	0.19	0.51
3	57.23	1.68	11.42	55.82	2.32	10.97	-1.41	0.64	-0.45	1.61
4	55.65	2.52	11.33	47.97	2.43	14.7	-7.68	-0.09	3.37	8.39
5	56.8	1.82	10.63	55.77	1.86	11.29	-1.03	0.04	0.66	1.22
6	57.46	1.76	11.23	56.09	2.05	11.28	-1.37	0.29	0.05	1.40
7	54.26	1.74	10.48	43.49	1.87	15.21	-10.77	0.13	4.73	11.76
8	56.67	1.75	11.14	54.65	2.42	11.45	-2.02	0.67	0.31	2.15
9	56.99	1.63	10.95	56.69	2.2	10.89	-0.3	0.57	-0.06	0.65
10	54.64	1.76	10.77	49.34	2.08	14.13	-5.3	0.32	3.36	6.28
11	56.46	1.67	11.31	55	2.52	10.63	-1.46	0.85	-0.68	1.82
12	56.74	1.85	10.8	55.2	1.9	11.14	-1.54	0.05	0.34	1.58

Table 8: Colour changes of samples after the fungal treatment with Pencillium.

with polymers without fungicides are less than the changes in the colour of unconsolidated samples. These results show that all tested polymers without fungicides lead to a reduction in the fungal deterioration of linen samples but do not prevent fungal deterioration completely. These results are in agreement with previous studies.[18] The data in Tables 6-8 show that there are no considerable changes in colour of the linen samples consolidated with polymers combined with fungicides after the deterioration with all tested fungi and confirm that fungal deterioration of linen samples was prevented completely.

There are obvious excessive fungal infestations in all tested textile objects in storage areas of both the Coptic Museum and the Egyptian Museum. The textile collections in storage rooms in the Coptic Museum are more infested by fungi than in the Egyptian Museum. The dominant fungi isolated from tested samples belong to *Aspergillus, Penicillium, Chaetomium, Alternaria* and *Trichoderma* species. The order of occurrence of fungi on linen textile fabrics is: *Aspergillus* > *Chaetomium* > *Penicillium* > *Alternaria* > *Trichoderma viride*. The order of occurrence of fungi on wool fabrics is: *Aspergillus* > *Penicillium* > *Chaetomium* > *Alternaria*.

There is a need for fungicide treatments to be used for disinfection of the biodeteriorated textiles and for polymers to be used in conservation of textile objects. The tested polymers containing one of the tested fungicides are very effective in prevention the fungal deterioration of textiles. This study should be followed with another study to evaluate the long term effect of tested polymers combined with fungicides on the properties of dyed and undyed textiles.

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