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Evaluation of using Klucel G on the Mechanical and Chemical properties of Sycamore wood

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Abstract

This paper describes the effect of using Klucel G dissolved in ethyl alcohol (ethanol)concentration of 1 , 2% on some samples of thermally and photo aging sycamore wood, Which is famous for its use in the manufacture of wooden coffins in ancient Egypt, and assessing its efficiency on some mechanical and chemical properties of sycamore wood through the use of some tests and analyzes were used to evaluate the concentrations of Klucel G using examination with a Scanning Electron Microscope (SEM) to define the surface changes before and after samples consolidation, and measuring pressure forces(Mechanical Properties) and Using Fourier-Transform infrared Spectroscopy (FTIR) analysis, the results of the tests and analyzes showed an improvement in the mechanical and chemical properties of the aging thermally and photo aging sycamore wood samples treated with Klucel G 1% concentration . The obtained data were used to evaluate the deterioration status of the coffin and to establish suitable treatment methods.

Key words:

Ficus Sycomorus, Mechanical Properties, Klucel G, FTIR, SEM

Introduction

Sycamore wood is one of the most important trees that the ancient Egyptian relied on in the manufacture of wood used in the roofing of houses and wooden skis used in transporting goods and stones, and was also used in the manufacture of wooden statues [1] , Sycamore wood is flexible and easy to shape, and for this reason it is considered suitable for making wooden sculptures, and one of its disadvantages is the large amount of water inside it, which makes it susceptible to decomposition by fungi and damage by insects, as well as being highly and rapidly affected by sudden changes in temperature and surrounding relative humidity [2] .

Hydroxypropyl cellulose It is a polymer of one of the derivatives of cellulose that was introduced into the antiquities field in 1980 to perform strengthening work for weak artifacts, It is a non-ionic cellulose ether[3] , manufactured in the United States of America under the name Klucel G, and in Japan it is found under the name of NISSO HPC[4] , It is prepared by reaction of Alkali cellulose with propylene oxide at high temperatures and pressures, Hydroxypropyl cellulose has been used in the field of restoration and maintenance of antiquities recently, and it does not cause problems in the future for the antiquities treated in the museum medium, Hydroxypropyl cellulose is used as a preconsolidant and preparation layer for methylcellulose [5] .

Hydroxypropyl cellulose is added to the candles to raise the viscosity of the mixture and improve its hardness and cracking tolerance when making paints from it, Klucel G is used as a preferred material in the field of restoration, as its viscosity ranges between (75-400 cp) at a temperature of 20 degrees Celsius in 2% ethanol in order to strengthen the colors [6] ,It is used to strengthen and protect water-soluble colors or to make a lining that does not have very strong properties [7] , and when it dries, it becomes matte and does not change colors, so it is used to strengthen dark colors [8], Where it was previously used with a concentration of 2% in ethanol as a tonic for coloring materials, and this method is an aqueous treatment and does not cause any problem when used, It is preferable to use cellulose derivatives dissolved in alcohol when the color media is animal glue[9] , It was also used to strengthen a multicolored sarcophagus dating back to the Greco-Roman era, and some colors were mediated by animal glue[10] .

Klucel G was used at a concentration of 5% with water in order to strengthen the wood of a multi-colored sarcophagus dating back to the first century on display in the Al-Arish Museum[11] ,It was also successfully used to strengthen the layers of a coffin belonging to the late 21st and early dynasty 22 (960-900 BC), where it was used to strengthen the layers of colors, as well as the gypsum layer and the clay and wood layers as well, and it proved its long-term stability, The cellulose films dissolved in alcohol showed low shrinkage (2-3%) while retaining their flexibility[12] .

Wood is composed of cellulose, hemicellulose and lignin [13-14], which are the basic components of wood composition, and all of them have distinctive spectra using infrared spectroscopy. Characteristic of the functional groups in wood are[15-16-17] : The cell wall of wood mainly contains cellulose, hemicellulose and lignin, and these components contain hydroxyl groups and hydrocarbon n groups [18-19], and these functional groups have distinct absorption spectra when spectroscopy. cm-1) as distinct absorption areas where it can be observed the changes that have occurred and the differentiation between their components [20-21-22] , and to facilitate the study of the infrared spectrum of the functional groups of the chemical components of wood, it has been divided into five distinct absorption areas [23-24]: Absorption area (2700-3600), Absorption area (1610-1750), Absorption area (1500-1610), Absorption area (1000-1500), Absorption area (400-1000).

2.Materials

2.1. Preparation of wood samples

The wooden samples were prepared from the same type of wood used in the manufacture of the coffin, which is sycamore wood, where the samples were cut into cubes of dimensions (5 x 5 x 5 cm) according to British specifications [9] , as shown in Fig No. (1), Standard specifications for aging: Since there is no standard specification for thermal aging of wood, the standard specification for paper made from wood pulp has been used due to the similarity of chemical compounds between them: (temperature 80 ° C and relative humidity 65%) (BS 6388-3:1996 - ISO 5630 -3:1996, Paper and board -- Accelerated ageing -- Part 3: Moist heat treatment at 80 degrees C and 65 % relative humidity Paperback), Exposure time: Aging for 120 hours (5 days) continuously The equivalent of 25 years in natural conditions, and Lamp type: Mercury-ARC Lamp (E40 - Mix F 500 W) was used. Standard specifications for aging: Light aging was used for 120 hours (5 days) continuously.

The samples were divided into 11 samples: (ST) standard sample, (STA) standard thermal aging sample, (STL) standard photo aging sample, (KG2A) klucel g 1% sample, (KG2AA) klucel g 1% thermal aging sample, (KG2L) klucel g 1% sample, (KG2LL) klucel g 1% photo aging sample, (KG3A) klucel g 1.5%sample, (KG3AA) klucel g 1.5% thermal aging sample, (KG3L) klucel g 1.5% sample and (KG3LL) klucel g 1.5% photo aging sample.

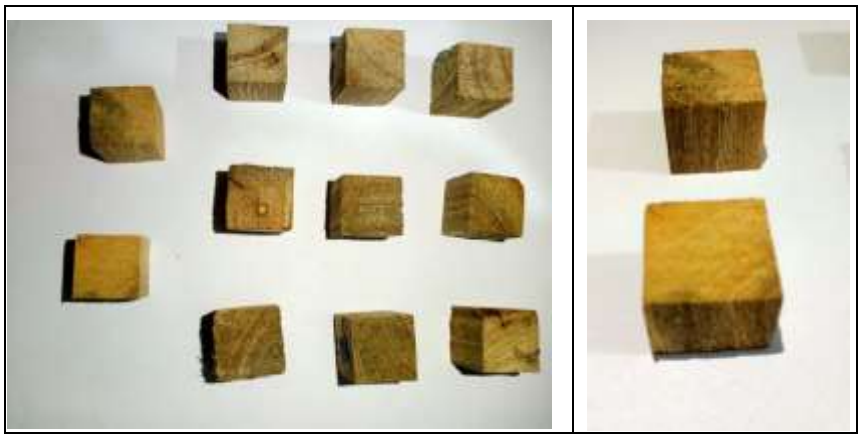


Fig No. (1) shows the shape of the samples used in the experimental side of the study

2.2. Preparation of klucel g

Klucel G was prepared at concentrations of (1,1.5%) by dissolving it in ethyl alcohol (ethanol). By adding a certain volume of Klucel G to the ethyl alcohol to reach the desired concentration.

3. Methods

3.1. Scanning Electron Microscope (SEM).

A scanning electron microscope was used MODEL: **JEOL JSM 5400LV EDX Link ISIS-Oxford "high vacuum,** The aim of this examination is to identify the surface changes of sycamore wood before and after strengthening and aging processes**.**

3.2. Measurement of Mechanical Properties.

Samples were prepared with dimensions of)2 x 2 x 2 cm (, The mechanical properties (compression) test was carried out with a Galdabini-Quasar 600-made in Italy and measured in N/mm2 The working conditions (Load Range: 10000N, Extension Range: 10mm, Speed: 50 mm / min, Endpoint: 5.0 mm, preload: 1.0N). The test was conducted at The National Institute of Measurement and Calibration, Giza, Egypt.

3.3. Fourier-Transform infrared Spectroscopy (FTIR)

Wood samples were analyzed using an infrared spectrophotometer Nicolet 380 FT-IR , It is the study of the chemical changes of the functional groups of each of the wood components of cellulose, hemicellulose and lignin by comparing the intensity and areas of the absorption spectrum of the functional groups characteristic of them for treated samples and standard samples.

4. Results and Discusstion

4.1. Scanning Electron Microscope (SEM).

Fig (3) Shows the SEM images a magnification of 200x of Klucel g 1% and Klucel g 1.5% thermal aging . (A) Standerd sample ST, (B) Thermal sample STA, (C) KG2A sample, (D) KG2AA sample,(E) KG3A sample, (F) KG3AA sample

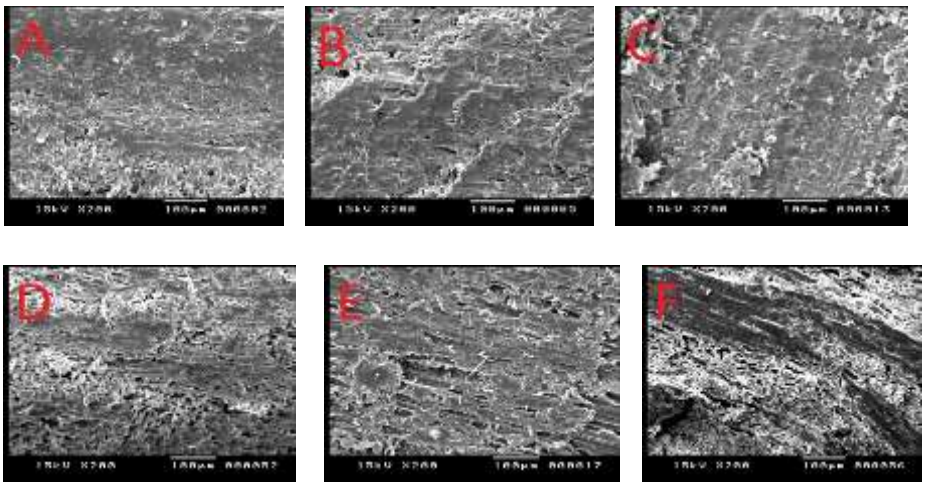


Figure No. 3 shows the scanning electron microscope examination of Klucel G samples with a concentration of (KG2AA) klucel g 1% thermal aging sample, (KG3AA) klucel g 1.5% thermal aging sample s before and after hardening and after thermal aging and comparing the samples through the surface changes that occurred on the surface of the samples and the extent of the penetration of the consolidate material. After its application, as well as after thermal aging, this is due to the stability of the concentration of klucel G to the temperatures, as well as the absence of any gloss produced on the surface of the samples after the application of klucel G.

Fig No (4) Shows the SEM images a magnification of 200x of Klucel g 1% and Klucel g 1.5% photo aging . (G) Photo sample STL, (H) KG2L sample , (I) KG2LL sample, (J) KG3L sample,(K) KG3LL sample

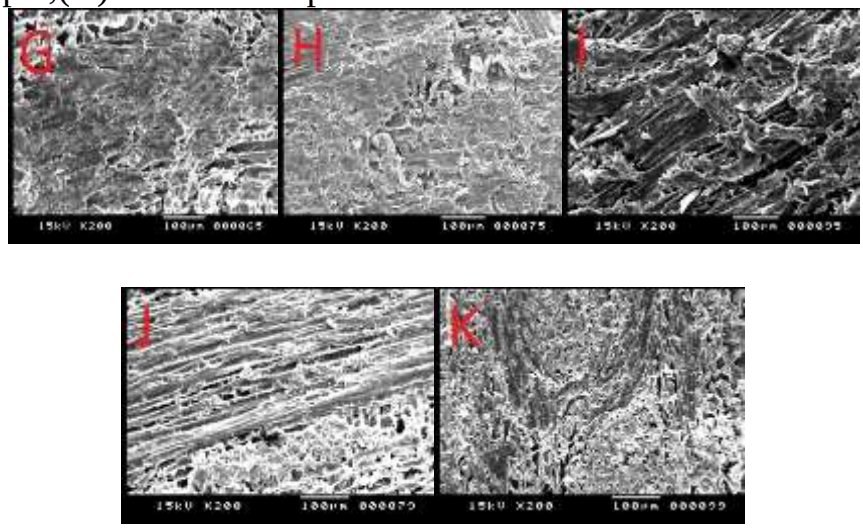


Figure No. 4 shows the Scanning Electron Microscope examination of Klucel G samples with a concentration of (KG2LL) klucel g 1% photo aging sample and (KG3LL) klucel g 1.5% photo aging sample. before and after hardening and after photo aging and comparing the samples through the surface changes that occurred on the surface of the samples and the extent of the penetration of the consolidate material. After its application, as well as after photo aging, this is due to the stability of the concentration of Klucel G to the light, as well as the absence of any gloss produced on the surface of the samples after the application of Klucel G.

4.2. Measurement of Mechanical Properties.

Table No. (1) shows the pressure tests of the standard sample and heat aging samples

M	Sample	Stress endurance (kg/mm2)	Stress endurance (N/mm2)
1	ST	428.07	4198
2	STA	338.13	3316
3	KG2A	293.16	2875
4	KG2AA	365.87	3588
5	KG3A	408.29	4004
6	KG3AA	411.25	4033

The results of measuring the mechanical properties showed varying changes in the values of the mechanical properties of the samples treated with reinforcement compared to the standard sample, whether samples after hardening or thermally aging after hardening. Standard (ST) (428.07 kg/mm2), where it was found that some samples had an increase in the ability to resist pressure forces, as the reinforcement sample Klucel G recorded a concentration of 1.5% (KG3A) the highest measurement (408.29 kg/mm2), then followed by a 1% Klucel G sample (KG3A) (293.16 kg/mm2).) . The results of the compressive strength of the reinforcing and thermally aging samples compared to the standard sample (428.07 kg/mm2) (ST), The results of the compressive strengths of the reinforcing and thermally aging samples compared to the standard sample (428.07 kg / mm 2) (ST), where it was found that some had a slight effect on the mechanical properties of some samples after showing the reinforcement with the hardening materials for aging, Where the Klucel G sample recorded the highest concentration of 1.5% (KG3AA) (411.25 kg / mm2), then followed by Klucel G sample of concentration of 1% (KG2AA) (365.87 kg / mm2).

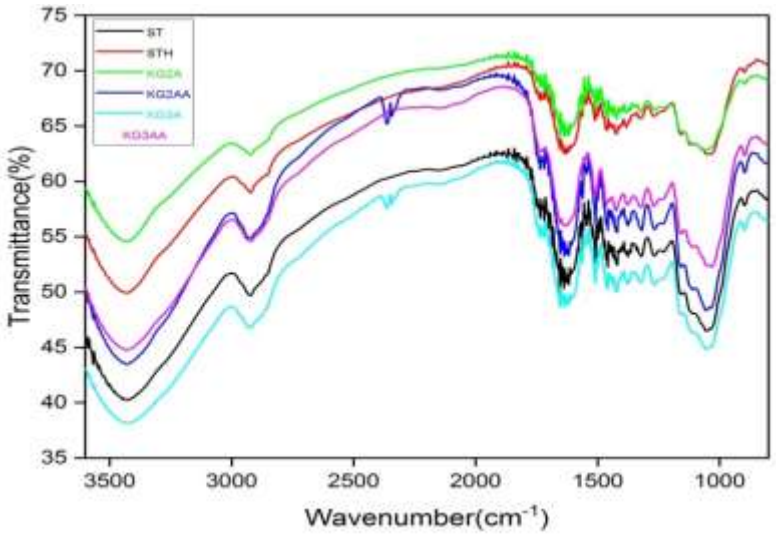
Table No. (2) shows the pressure tests for standard and photo aging samples

M	Sample	Stress endurance (kg/mm2)	Stress endurance (N/mm2)
1	**ST**	428.07	4198
2	**STL**	331.30	3249
3	**KG2L**	349.55	3428
4	**KG2LL**	436.13	4277
5	**KG3L**	380.86	3735
6	**KG3LL**	293.16	2875

The results of measuring the mechanical properties showed varying changes in the values of the mechanical properties of the samples treated with reinforcement compared to the standard sample, whether samples after hardening or photo aging after hardening. mm 2), where it was found that some samples had an increase in the ability to resist pressure forces, where the reinforcement sample Klucel G concentration of 1.5% (KG3A) recorded the highest measurement (380.86 kg / mm2), then followed by Klucel G sample 1% concentration (KG2A) (349.55 kg / mm2). The results of the compressive strength of the reinforcing and thermally aging samples compared to the standard sample (428.07 kg/mm2) (ST), The results of the compressive strength of the reinforcing and optically aging samples compared to the standard sample (428.07 kg/mm2) (ST), where it was found that some samples had a slight effect on the mechanical properties of some samples after exposure of the samples reinforced with consolidated materials to light aging, where a sample recorded Klucel G 1% concentration (KG2LL) (436.13 kg / mm2), then followed by the reinforcement sample klucel G 1.5% concentration, the highest concentration (KG3LL) (293.16 kg). /mm2).

4.3. Fourier-Transform infrared Spectroscopy (FTIR).

Figure (5) shows the results of spectral analysis of the treated samples compared to the standard samples after thermal aging



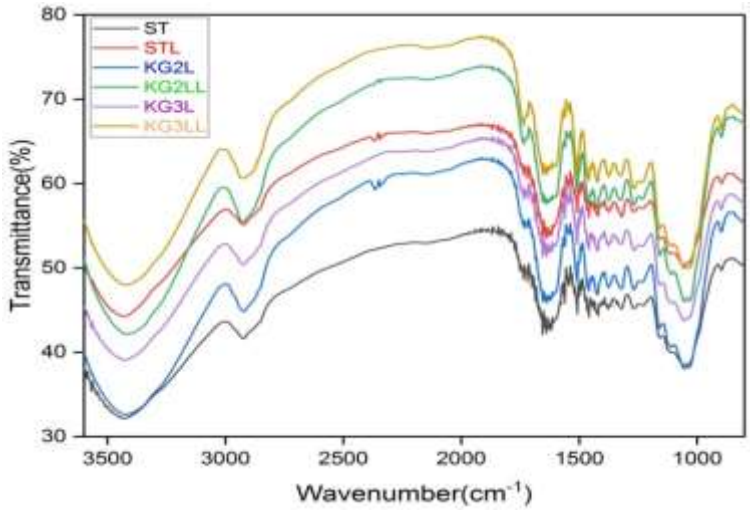
It is evident from the results of the previous analysis that:

- The absence of a C-H oscillation spectrum (896 cm-1) for the KG2A sample and the STA sample compared to the standard sample ST and the rest of the treated samples.

- A significant decrease in the intensity of tidal C = O, which indicates a significant change in the proportion of hemicellulose and a displacement of 17 cm-1 for sample KG2A compared to the standard sample ST and the rest of the treated samples, A slight decrease in the intensity of tidal C = O, which indicates an unnoticeable change in the proportion of hemicellulose and a displacement of 2 cm-1 for KG3A sample compared to the standard sample ST, and it was not present in the STA sample.

- A decrease in the amplitude of the O-H extension as a result of a decrease in the intensity of the treated samples compared to the standard sample ST, with the appearance of a second absorption region for samples KG2AA, KG2A compared to the standard sample that is located in one absorption area at an absorption area (3423 cm-1) where there are two absorption areas for samples The treatment where it is found in the absorption area (3430 cm-1) and the second absorption area (3448 cm-1), An increase in the amplitude of the O-H stretch as a result of an increase in the intensity of the treated samples compared to the standard sample ST, with the appearance of a second absorption region for the KG3A sample compared to the standard sample that is located in one absorption region at an absorption region (3423 cm-1) where there were two absorption regions for the treated sample KG3A Where it is located in the absorption area (3430 cm-1) and the second absorption area (3448 cm-1), Where there was an increase in the intensity of absorption for all absorption areas of the sample KG3A.

Figure (6) shows the results of spectral analysis of the treated samples compared to the standard samples after photo aging



It is evident from the results of the previous analysis that:

- A slight decrease in the intensity of tidal C = O, which indicates a slight change in the proportion of hemicellulose and a displacement of 2 cm-1 for all treated samples compared to the standard sample ST, A slight decrease in the intensity of tidal C = O, which indicates a slight change in the proportion of hemicellulose and a displacement of 2 cm-1 for sample KG3LL compared to the standard sample ST and the rest of the treated samples.

- Decrease in O-H tidal amplitude as a result of a decrease in intensity for KG2LL sample compared to the standard sample ST and a displacement of 4 cm-1, an increase in the absorption intensity of KG2L sample and an increase in O-H tidal amplitude and a displacement of 2 cm-1, A decrease in the amplitude of the O-H extension as a result of a decrease in the intensity of the treated samples compared to the standard sample ST, with the appearance of a second absorption area for KG3L samples compared to the standard sample that is located in one absorption area at an absorption area (3423 cm-1) where there are two absorption areas for the treated sample where It is found in the absorption zone (3423 cm-1) and the second absorption zone (3448 cm-1).

Conclusion

During this paper, the effect of using Klucel G concentration of 1%, 1.5% in ethyl alcohol on improving the mechanical and chemical properties of sycamore wood samples after thermal and Photo artificial aging processes was studied, The pressure forces of the wood samples were measured, as well as the use of SEM Scanning Electron Microscope to find out the surface changes and the use of FTIR to define the changes of the chemical composition of wood and the functional groups of cellulose, hemicellulose and lignin, Where the results showed a significant improvement of the concentration of Klucel G at a concentration of 1% in ethanol,

The pressure strength for thermal aging samples gave KG2A 293.16kg/mm2, kG2AA 365.87kg/mm2 and photo aging samples KG2L 349.55kg/mm2, KG2LL 436.18kg/mm2 Compared to standard sample ST 428.07kg/mm2, as well as the absence of chemical changes for the functional groups of the hydroxyl groups OH and the carbonyl group C=O,both in cellulose, hemicellulose and lignin as it is proven by FTIR Analysis.

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