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New Application of Polyurethane Polymers for Consolidation of A Deteriorated Oil Painting of Salvator Rosa

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THE OIL painting "Scene of a Battle" executed by famous Italian Baroque painter Salvator Rosa (1615 - 1673) on a canvas support. It was weak, had cleavages, cracks, separation between the layers, and also blind cleavage in many sections. Scanning electron microscope (SEM), x-ray diffraction (XRD), energy dispersive analysis of x-rays (EDAX), fourier transform infrared (FT-IR) and carbon-13 nuclear magnetic resonance (^{13}CNMR) analyses were applied on micro fragments. The obtained results indicated that the artist used canvas of linen, calcium carbonate mixed with animal glue for the preparation of background of the paintings. The main pigments of the paint layers are iron aluminum silicate for red, iron sulfate for yellow, calcium iron oxide for yellowish green, lead carbonate hydroxide for white, carbon for black, mixed with linseed oil for painting. Laboratory study was carried out on six polymers of polyurethane to select the best one to be used for the consolidation of the oil painting. Its physical characteristics (color changes and tensile properties) in addition to chemical structure were determined before and after exposure to artificial aging. The results indicate that Idrocap 990 polyurethane polymer gave more improvement in strength and stiffness and had a high stability against artificial aging processes and safe to use for restoration and preservation of oil paintings. Based on the obtained results, the oil painting was treated and restored. The consolidation process of the oil painting was carried out using Idrocap 990 polyurethane polymer to restore the bond between all structural elements of the oil painting. The polymer was applied by using a small brush along the cleaved paint and into the cracks, or applied using a syringe in the case of blind cleavage to inject the polymer from the canvas reverse. The consolidation process is a suitable solution for the oil paintings which suffer from weakness and had cleavages.

Keywords: Oil painting, Salvator Rosa's painting technique, Conservation, Restoration, Consolidation, Polyurethane.

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The oil painting which is the subject of the study "Scene of a Battle" on a canvas support belongs to the fine art museum in Alexandria, registration number 64 (Fig. 1). Its dimensions are 73.50cm by 52.3cm. It was executed in the seventeenth century, by the famous Italian Baroque painter Salvator Rosa (1615-1673), who was also a poet and printmaker, active in Naples, Rome and Florence. As a painter, he was best known as an "unorthodox and extravagant" and a "perpetual rebel"[(1)] . The Baroque is an artistic style prevalent from the late 16^{th} century to the early 18^{th} century[(2)] . Baroque art is characterized by great drama, rich, deep color, and intense light and dark shadows. As opposed to Renaissance art, which usually showed the moment before an event took place, Baroque artists chose the most dramatic point, the moment when the action was occurring. Baroque art was meant to evoke emotion and passion instead of the calm rationality that had been prized during the Renaissance[(3)] .

Fig. 1. General view of the oil painting "Scene of a Battle", the subject of the study.

The oil painting was lined before, but the previous lining was damaged and separated in many parts causing further risk to the painting. Several deterioration features existed in the oil painting, the main damage is its weakness whish caused cleavages and cracks in the paint layer (Fig. 2), in addition to separation between paint and ground layer and between ground and support in some parts (Fig. 3).

Fig. 2. Cracks and cleavages in the paint layer that distorted the painting surface.

Fig.3. Loss of the adhesion between the paint and ground layer, therefore, some parts of the paint layer of the ground layer have fallen.

There was also blind cleavage in many sections around the edge of the support (Fig. 4). Cleavage is an area of the paint or paint and ground that is lifted completely from the support, but blind cleavage is a blister like condition similar to cleavage except that the paint may not be cracked on the surface, this can be caused by any number of things: poor-quality mediums or paints, moisture in the ground, or mechanical damage (Fig. 5)[4] .

Fig.4. The blind cleavage in many sections around the edge of the support.

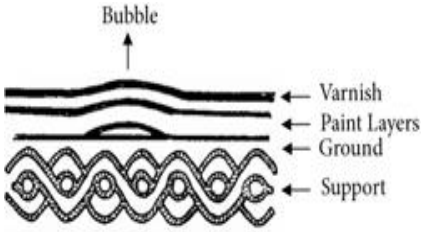

Fig.5. Blind cleavage is a blister like condition similar to cleavage except that the paint may not be cracked on the surface.

Mechanical agents caused marked buckling, rippling and creases. Corresponding to the damages to the fabric, were cupping, lifting and flaking of the paint and ground layers down to the canvas. The oil painting is covered with a dark brownish varnish. Therefore, the oil painting requires consolidation which includes re-adhering lifted or cleaving areas of the paint and/or ground layers. Adhesive can be introduced with a variety of methods including a small brush or syringe[(5)] .

Polyurethane polymers products have many uses and have been used as adhesives[(6)]. These synthetic polymers have found sporadic use in the conservation field as well, specifically for consolidating fragile materials. Properties such as permanence, stability, and reversibility are important for the conservator, and not always important in industry; yet often these materials have been adapted for use in conservation without extensive testing. So, it was selected to study the using of it to consolidate the weak oil paintings in all layers.

Polyurethanes are found in the class of compounds called reaction polymers, which include epoxies, unsaturated polyesters, and phenols[(7)] . It is commonly abbreviated as PU. It is any polymer consisting of a chain of organic units joined by urethane (carbamate) links. Polyurethane polymers are formed through step-growth polymerization by reacting a monomer containing at least two isocyanate functional groups with another monomer containing at least two hydroxyl (alcohol) groups in the presence of a catalyst. Its formulation covers an extremely wide range of stiffness, hardness, and densities [(8)] .

The aim of this article is to study polyurethane polymers to consolidate and reinforce the weak oil painting and badly tented paint layers. In addition to the consolidation of this archaeological oil painting by a safe, easy and active method. This offered the unique possibility to carry out a suitable scientific investigation aimed at a satisfactory knowledge of the employed materials and their chemical evolution along the centuries and understanding its painting technique.

Materials and Methods

The case study

The archaeological oil painting "Scene of a Battle" was studied, microfragments of the painting layers, whose dimensions were smaller than $1mm^2$ were collected from the paint and background in correspondence to superficial crackings in order to characterise the pictorial technique and possible superimposed layers. Moreover samples were collected from the strongly yellowed varnish with appropriate solvents (*i.e.* acetone, methanol, and isopropanol) to identify the nature of the varnishes and to evaluate their possible alteration processes. Also fragments of canvas textiles support were collected to identify the canvas fiber.

Scanning electron microscope (SEM), x-ray diffraction (XRD), energy dispersive analysis of x-rays (EDAX), fourier transform infrared (FT-IR) and carbon-13 nuclear magnetic resonance (^{13}CNMR) analyses were carried out to identify the oil painting layers.

Polymers

Six polymers of polyurethane were studied to select the best one to consolidate the oil painting, the selected polymers are as following [9] :

1. Idrocap 954: A medium soft poly urethane with very good general properties. It is particularly suitable for finishing or impregnation when a "full" hand is requested. Anionic polyurethane in aqueous dispersion for direct resin coating. Used for general applications.
2. Idrocap 990: Rigid aliphatic polyurethane in aqueous dispersion. Suitable for direct resin-coating or as top skin for transfer application. Also, can be used as cuttable product due to its high rigidity.
3. Idrocap 995: Water borne aliphatic polyurethane. Particularly suitable for finishing or impregnation when a dry or hard touch is required. Applied also as top-skin for high-gloss lacquers. It is a very hard polyurethane with very good general properties, and particularly suitable for finishing or impregnation when a dry and hard hand is requested. It is used in the coating field as high gloss binder for water based paints and varnishes.
4. Witcobond 234: A stable dispersion of anionic polyurethane in water. The polymer is prepared from polyester polyol and aliphatic diisocyanate to give films and coatings which are tough and abrasion resistant. Witcobond 234 can be used for various substrates including plastics, wood, metal, natural and synthetic leather (top coats).
5. Witcobond 755: A stable, high solids dispersion of polyurethane in water. The polymer is prepared from polyester polyol and aliphatic diisocyanate to give films and coatings which are very soft and flexible. Witcobond 755 can be used in textile and leather coatings.
6. Witcobond 769: A stable dispersion of anionic polyurethane in water. The polymer is prepared from polyester polyol and aliphatic diisocyanate to give films and coatings which are soft and flexible.

The following criteria were set up for the polymers used in consolidation[10] : The adhesive must be able to penetrate into the finest craquelure or the microscopic openings in the paint and /or ground layers: it will be of a low viscosity, and not form any degradation products that might be harmful to the object, it must not cause undesirable changes to the surface appearance of the paint or polychromy, stable to the effects of light, temperature and humidity, able to be applied and handled using the usual methods for consolidation of the polychrome sculptures and other painted objects, such as brush or syringe, possible to remove any excess adhesive with solvents that are relatively harmless to the object.

The selected polyurethane polymers were exposed to artificial aging (heat, I.R., V.L., U.V. radiations and humidity), then its physical characters (color changes and tensile properties) were determined before and after exposure.

Also FT-IR analyses were carried out before and after exposure to artificial aging to determine the changes in their structure. This study focused on the practical reliability of six polyurethane polymers dispersions used frequently in paintings conservation. These adhesives were selected because they are readily available to the conservator. Properties of reversibility, color change, and changes in their structure were examined. Both aged and unaged samples were tested. Consideration of these data provided information about the long-term stability of these products.

Model

An oil painting model was prepared similar to the archaeological oil painting by scale 1:2 ratio, to carry out experimental tests on consolidation polymer before the application on the archaeological oil painting.

Results and Discussion

Identification of the oil painting layers

The observation by SEM of canvas support reveals that the fiber is linen (Fig. 6), the structure is plain weave 1/1, and threads are 20 for warp and weft/cm.

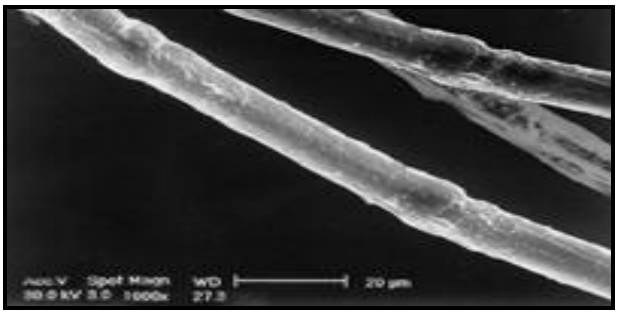

Fig.6. SEM micrograph showing that the fibers of canvas support is linen.

The results of X-ray diffraction analysis and EDAX that was carried out to identify the constituents of the background and paint layers, revealed that the painter used calcium carbonate, Calcite-III, $CaCO_3$ (17-0763) for the background. The main pigments in the paint layer consist essentially of the sample of red color: iron aluminum silicate, sekaninaite, $Fe_2Al_4Si_5O_{18}$ (31-0615), for the sample of the yellow color: iron sulfate, $Fe_2(SO_4)_3$ (42-0225), for the sample of the yellowish green color: calcium iron oxide, $Ca_4Fe_{14}O_{25}$ (13-0395), for the white color: lead carbonate hydroxide, hydrocerussite, $Pb_3(CO_3)_2(OH)_2$ (13-0131), for the sample of the black color: carbon, graphite, C (13-0148) (Figs. 7, 8).

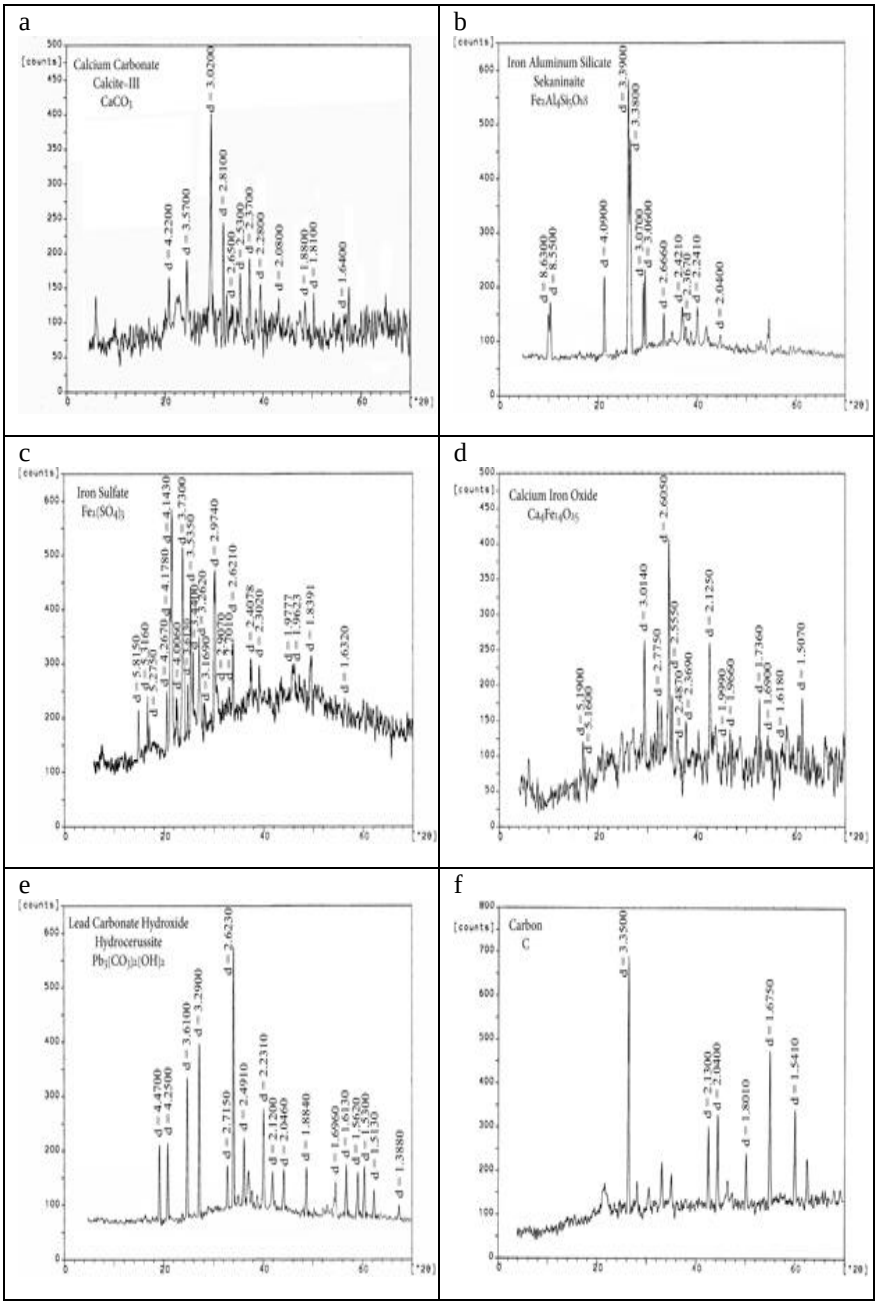

Fig. 7. XRD patterns of the ground layer (a) and main pigments (b-f) in the paint layers used in the oil painting.

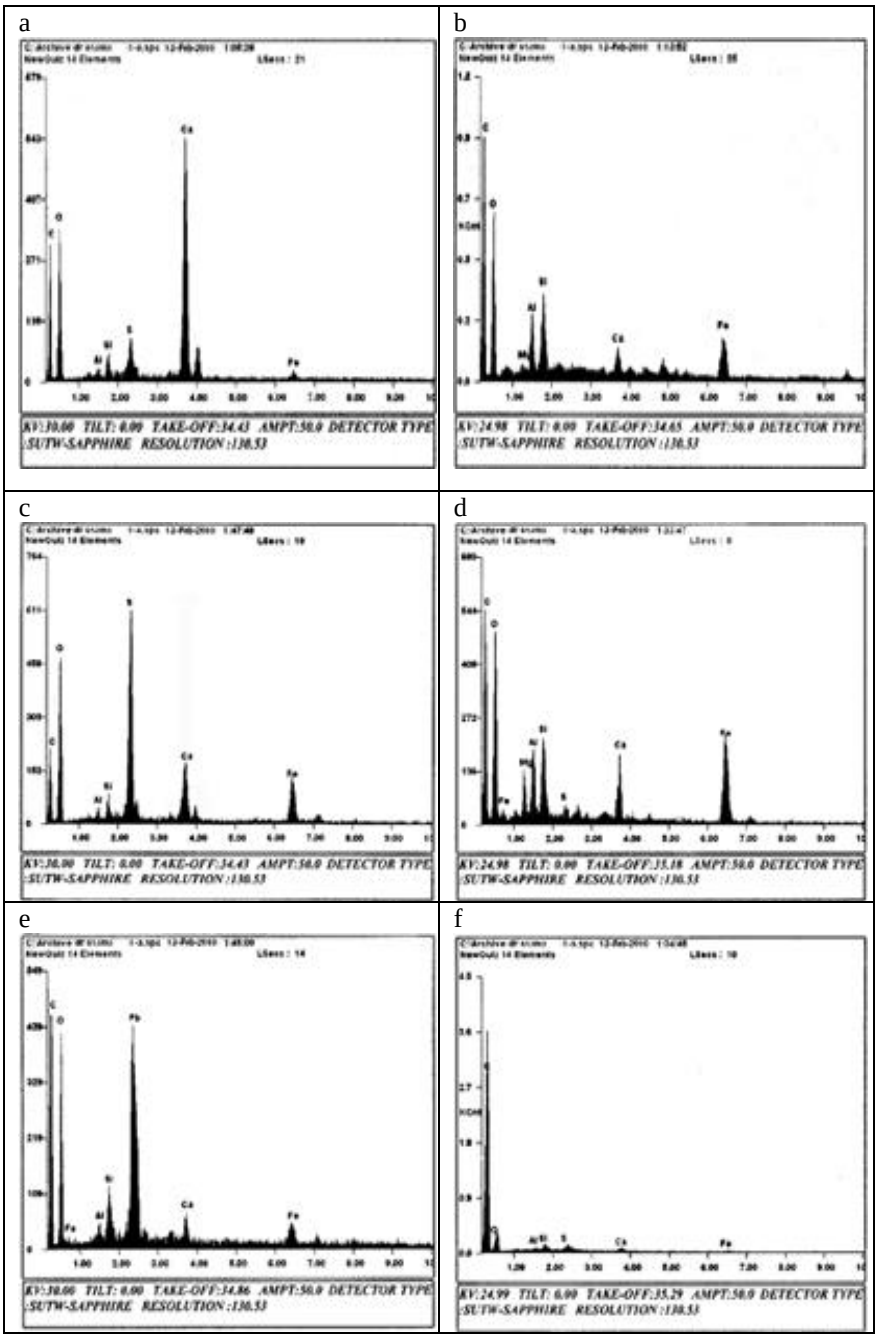

Fig. 8. EDAX patterns of the ground layer (a) and main pigments (b-f) in the paint layers used in the oil painting.

The study of the ground and paint layers of the oil painting by FT-IR spectroscopy reveals that animal glue is used as a binder in the round layer compared with new sample of animal glue, the stretching and bending absorptions of the proteins bands (broad band centred at 3308 attributed to stretching ν N–H, 1654 stretching ν C=O amide I and 1518 bending δ N–H amide II)[11] (Fig. 9).

Moreover, the medium used in the paint layer is linseed dry oil compared with new sample of linseed oil, the bands at 3423 is free COOH (fatty acid), 2926 & 2854 is C-H stretching vibration, 1460 is C-H bending vibration, also, the bands at 1738, 1165 and 1114 cm−1 could be attributed, respectively, to the C=O stretching and to the C–O stretching of the drying oils, a strong carbonyl band ν C=O at 1738cm−1 and the C–O stretching pattern at 1265cm−1 characteristic to the triglyceride ester linkage. The band at 1412 cm−1, related, respectively, to the asymmetric and the symmetric stretching of the carboxylate COO groups which may be attributed to the formation of carboxylic acids, formed by oxidative processes of the oils by time, 722 is (CH2)n group vibration [12], [13] (Fig. 10).

Analysis of the varnish layer by FT-IR spectroscopy showed that the varnish is shellac (natural resin) which proved through comparison with new resin, the bands at 3448 is O—H str alcohol, N—H str, 2927 is C—H str, 2857 is C—H str methyl, 2642 is O—H str carboxilic acids, 1718 is C=C str, 1655 is N—H bend amines, 1459 is C=C str aromatic rings, 1384 is C—H bend ring, 1257 is C—O str carboxilic acids, 1183 is C—O str carboxilic acids, 1103 is C—N str amines, 1023 is C—O str carboxylic acids, 556& 470 are C=C twist[14] (Fig. 11).

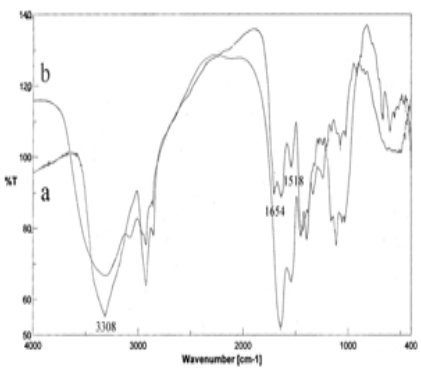

Fig.9. FT-IR patterns of the adhesive in the ground layer used in the oil painting (a), and standard of new animal glue (b).

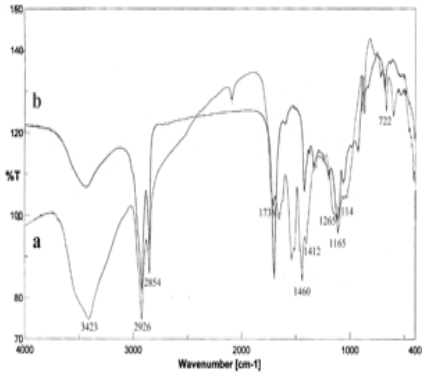

Fig.10. FT-IR patterns of the medium used in the paint layers in the oil painting (a), standard new linseed oil (b).

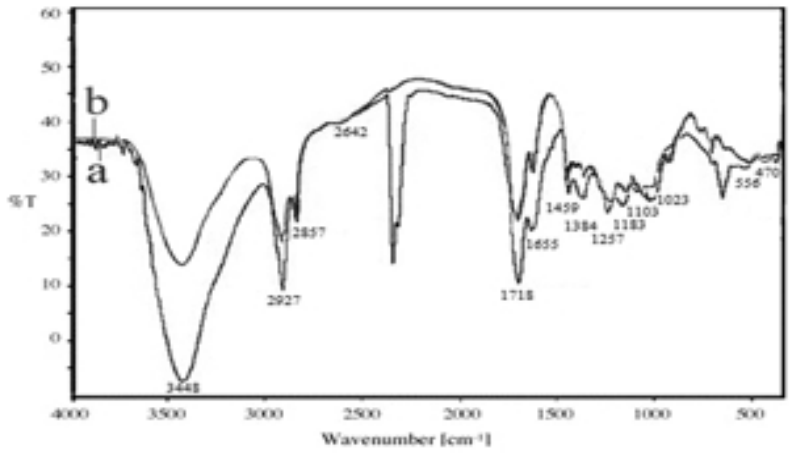

Fig.11. FT-IR patterns of the varnish layer (a), and standard new shellac varnish (b).

Using ^{13}CNMR analysis to ensure the result of FT-IR, upon reviewing the literature[15] , it was mentioned that shellac mainly consists of esters of aleuritic acid, shelloic acid or esters of aleuritic acid and jalaric acid, lac dye, the encrusted insects and twigs.

A sample of the varnish layer was dissolved in the least amount of ethyl alcohol, concentrated to 5 ml and screened on TLC (Silica gel aluminum sheets G 60 (F254-Merck)) using benzene : ethyl acetate (8:2) as solvent system. The TLC plates were examined under UV-254 nm and visualization was done by spraying with 10% H_2SO_4 and heated at 110 ^oC for 5 min.

TLC analysis of the sample showed several spots, the two main spots were isolated and purified using preparative TLC. And identified using ^{13}CNMR spectrometer (Nuclear Magnetic Resonance spectrometer), their structures confirmed in comparison with the published data[15] .

Compound I was isolated with R_f values 0.61cm in solvent systems BAW (4:2:1),^{13}C-NMR data (125 MHz, DMSO) (Fig. 12): δ 176.57 (C-1), 33.87 (C-2), 24.62 (C-3), 29.23 (C-4), 28.87 (C-5), 29.92 (C-6), 25.09 (C-7), 33.53 (C-8), 76.20 (C-9,10), 33.53 (C-11), 26.09 (C-12), 28.74 (C-13), 26.32 (C-14), 32.30 (C-15), 62.80 (C-16). Compound II was isolated with R_f values 0.73 cm in solvent systems BAW (4:2:1), ^{13}C-NMR data (125 MHz, DMSO) (Fig. 13): δ 169.84 (C-1), 135.10 (C-2), 137.42 (C-3), 70.09 (C-4), 51.45 (C-5), 51.22 (C-6), 29.00 (C-7), 23.26 (C-8), 54.97 (C-9), 38.26 (C-10), 46.66 (C-11), 31.26 (C-12), 178.78 (C-13), 68.16 (C-14), 22.88 (C-15).

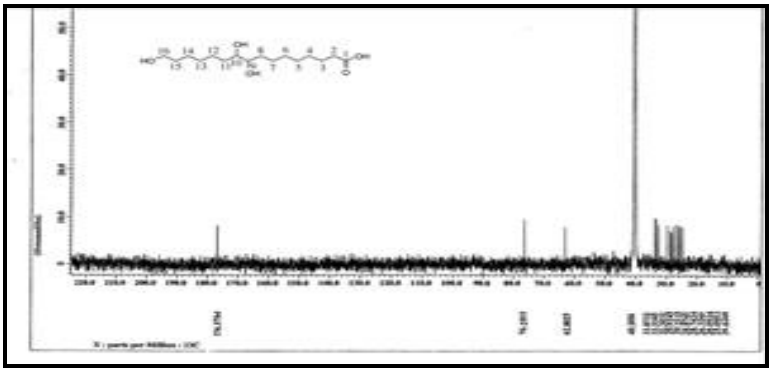

Fig. 12. ^{13}C-NMR spectrum of compound I.

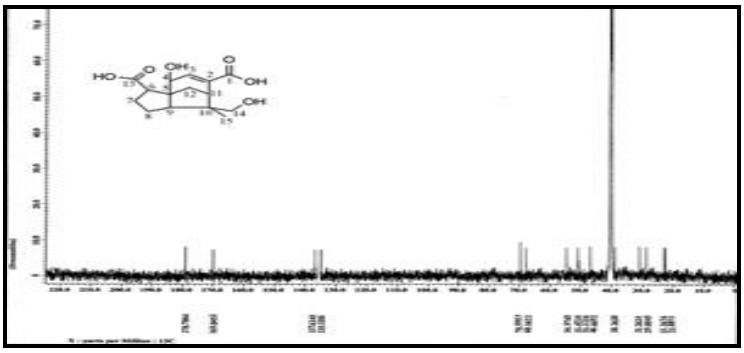

Fig. 13. ^{13}C-NMR spectrum of compound II.

Laboratory experiments

The experimental tests were carried out on the six polymers of polyurethane (Idrocap 954, Idrocap 990, Idrocap 995, Witcobond 234, Witcobond 755, Witcobond 769), con.10%, which will be used for the consolidation of the oil painting the subject of the study. The polymers of polyurethane were exposed to artificial aging in an oven at 75°C temperature for 300 hr. Solar box (xenon arc lamp I.R., V.L., U.V. radiations) at 100°C temperature for 300 hr. And in climatic chamber to (60°C temperature, 70% relative humidity, 360 nm U.V) continuously for 300 hr. Then the variations in color values and transparency were determined periodically in order to determine the relative rate of color changes of the polymers samples, the reflectance values were inserted into a computer program which calculated L, a, and b values. Calculation of total color change (ΔE) is achieved by the use of the following equations[16] : $\Delta E = [(\Delta L)^2 + (\Delta a)^2 + (\Delta b)^2]$, the curves of yellowness are presented in Fig. 14. Idrocap 990 appears to give somewhat better improvement in resistant than other materials of polyurethane that were studied and no change in color was indicated for it.

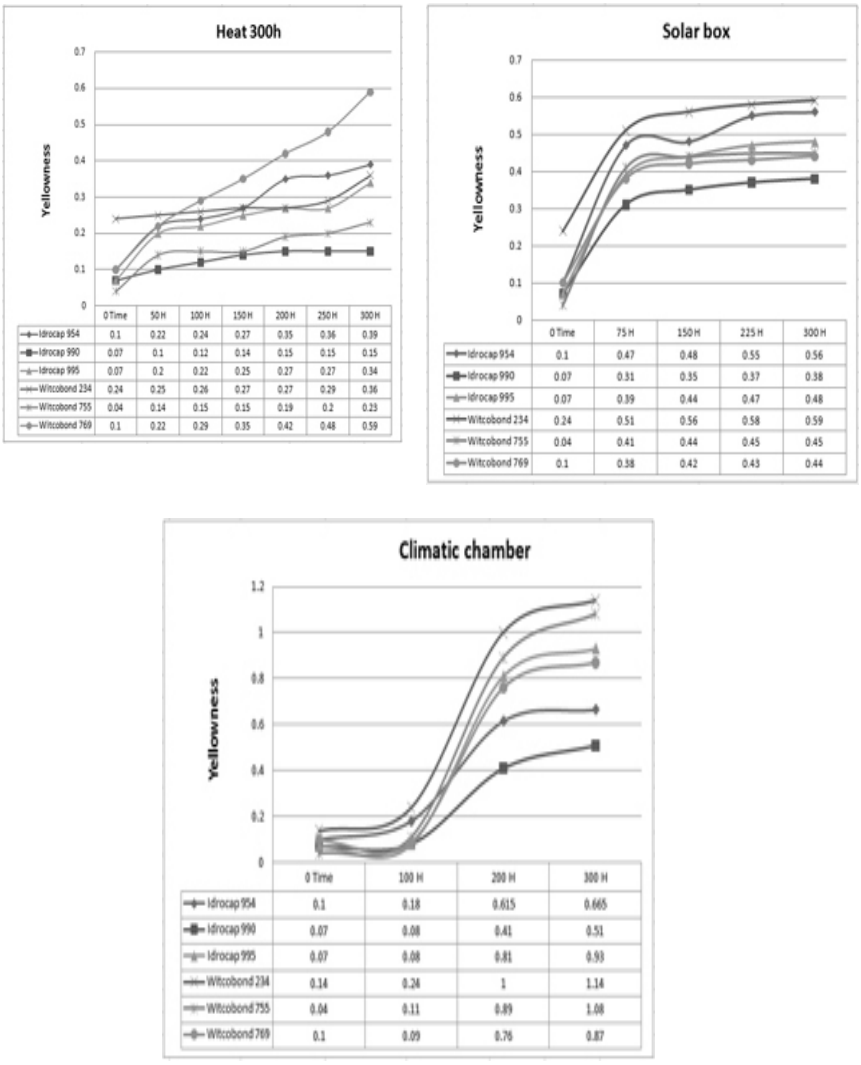

Fig. 14. Changes in the yellowing rate value of the six polyurethane polymers after exposure to artificial ageing, (a) after exposure to heat, (b) after exposure in solar box, (c) after exposure in climatic chamber.

Tensile Properties of polyurethane films have been majored before and after artificial aging in a climatic chamber at last conditions; the data are reported and illustrated in Fig. 15. The results refer that Idrocap 990 has a good properties and stable after aging.

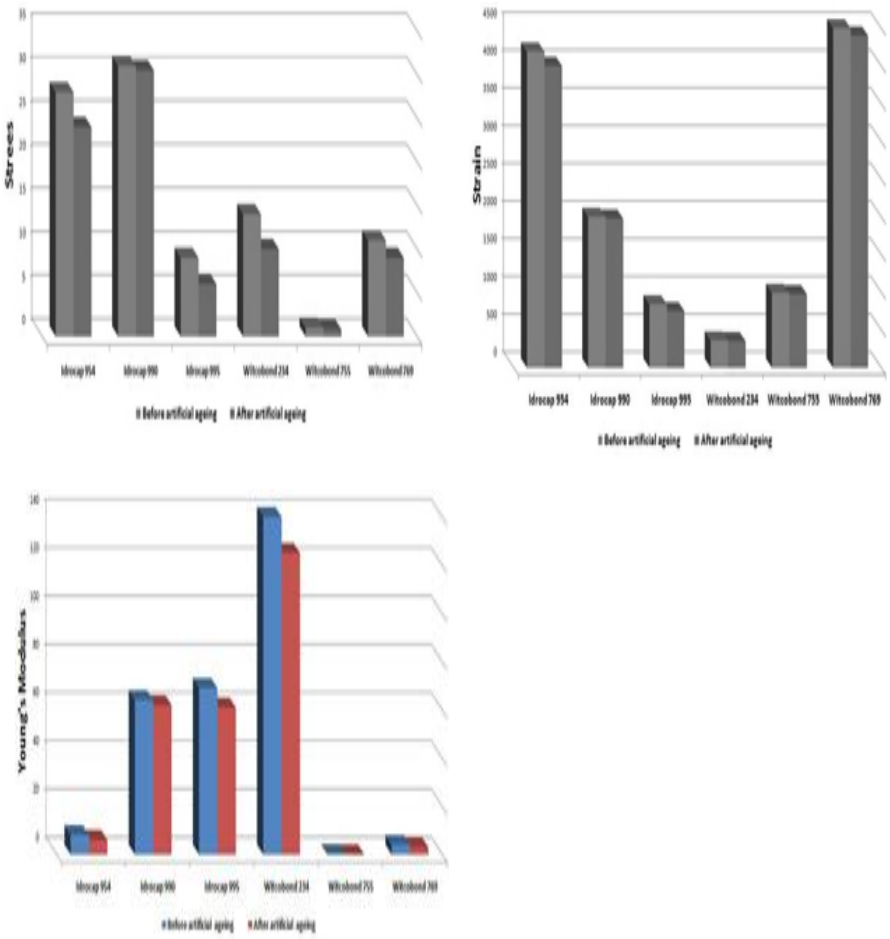

Fig. 15. The tensile properties of the six polyurethane polymers before after exposure to artificial ageing in climatic chamber.

Also FT-IR analysis was carried out before and after exposure to artificial aging to determine the changes in their structure[17] (Fig. 16). Idrocap 990 showed high stability against artificial aging processes, there were no significant changes in its structure. Following our discussions with polyurethane polymers, the testing decided that Idrocap 990 seemed to have the required working properties.

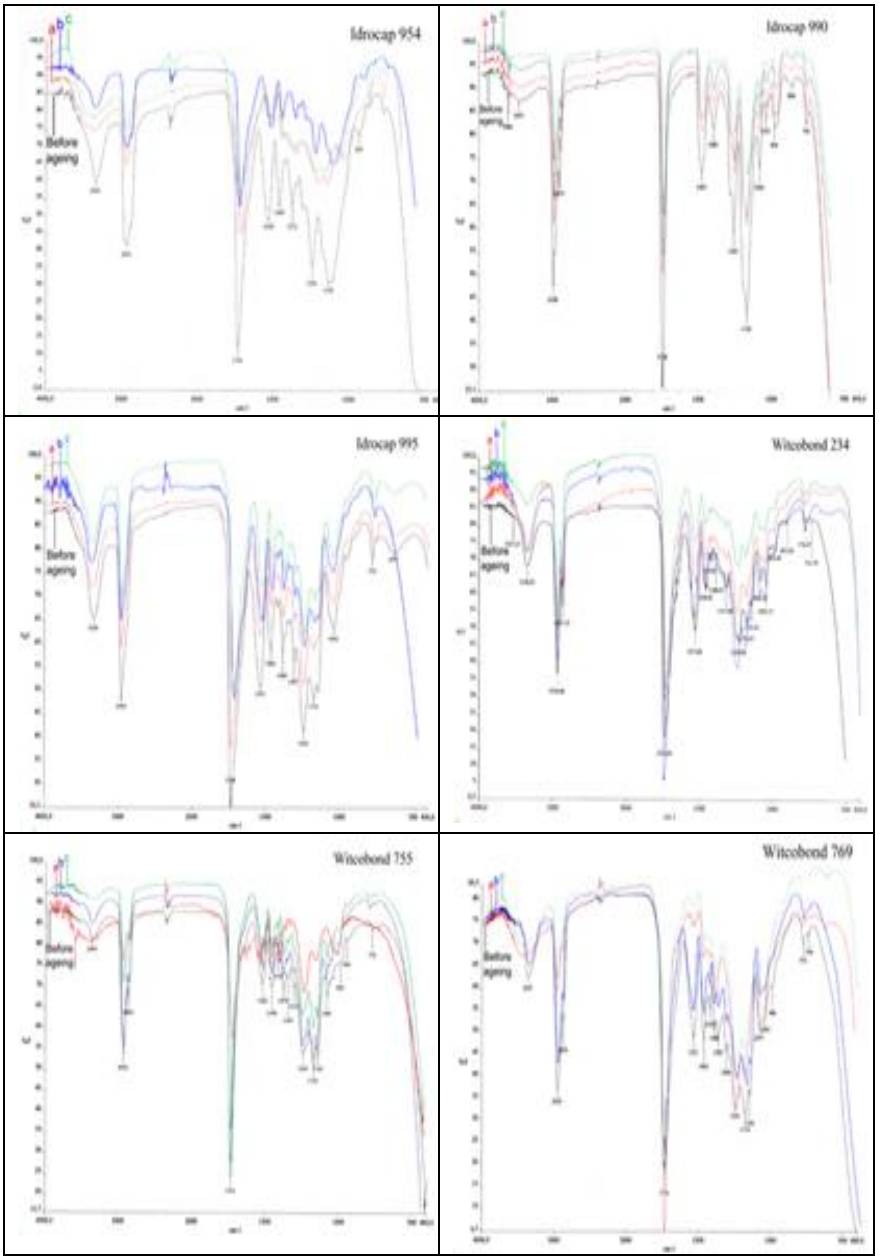

Fig. 16. FT-IR patterns of the six polyurethane polymers before and after exposure to artificial ageing, (a) after exposure to heat, (b) after exposure in solar box, (c) after exposure in climatic chamber.

An oil painting's model of the archaeological oil painting was exposed to artificial aging until the layers of the painting had become weak, and fine cracks had been appeared in the ground and paint layers, then four concentrations of Idrocap 990 that was succeeded through the previous experiments were used for the consolidation process of the oil painting model, the first one is 10% concentration, the second one is 20% concentration, the third one is 30% concentration, and the fourth one is 40% concentration on the four equal parts of the model, then the oil painting manufactured model was exposed to artificial aging represented by exposure to 50C temperature for 100 hr, then to the normal surrounding environment for 120 days, and the change in the polymer used in the consolidation was registered.

The results showed that Idrocap 990 at concentration 20% succeeded to consolidate the layers of painting and bind them more; showing high stability against artificial aging processes, and no change in its color. Whereas the area which was consolidated with 10% concentration of the polymer was still weak. And the area that consolidate with 30% and 40% concentration had a glossy appearance and hard effect, so the first concentration is the best one for the use in consolidates layers (Fig. 17).

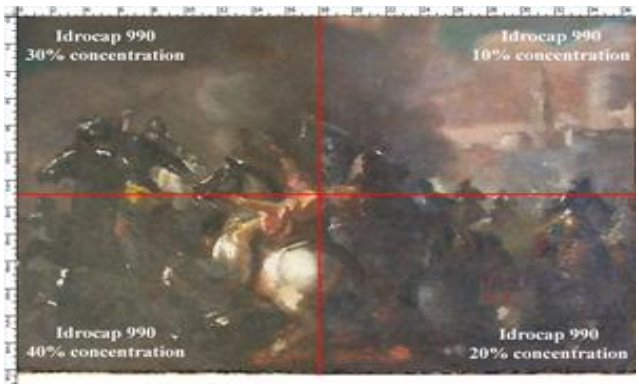

Fig. 17. The oil painting model after applying four concentrations of polyurethane polymers into four equal parts, then exposure to artificial ageing.

Restoration of the archaeological oil painting

The treatment and restoration was devised using materials that could be applied and removed without affecting one another. This included the following processes:

Removal of improper previous restoration

At first, removal of the gilded display frame and wooden stretcher frame from the back of the canvas oil painting. Then, removal of the new canvas support that was glued to the back side of the oil painting throw the previous lining process, the adhesive of lining and the additional canvas became weak and

brittle with time (Fig. 18); the previous lining was removed by pulling the canvas lining diagonally at a flat angle to the surface of the painting as possible, during the separation process, a colleague should keep the original canvas flat with the aid of a board, holding it as close as possible to the line of separation. The lining canvas is loosened along one side, cut into 2-3cm strips, and then pulled off in strips, old lining fabric was brittle (Fig. 19), scalpel was used to help in the strongly adhering pieces. After that, the remains of hard adhesive glue were removed mechanically by using the scalpel (Fig. 20).

Fig. 18. Separation of the original canvas of the additional support, especially in the edges of the oil painting.

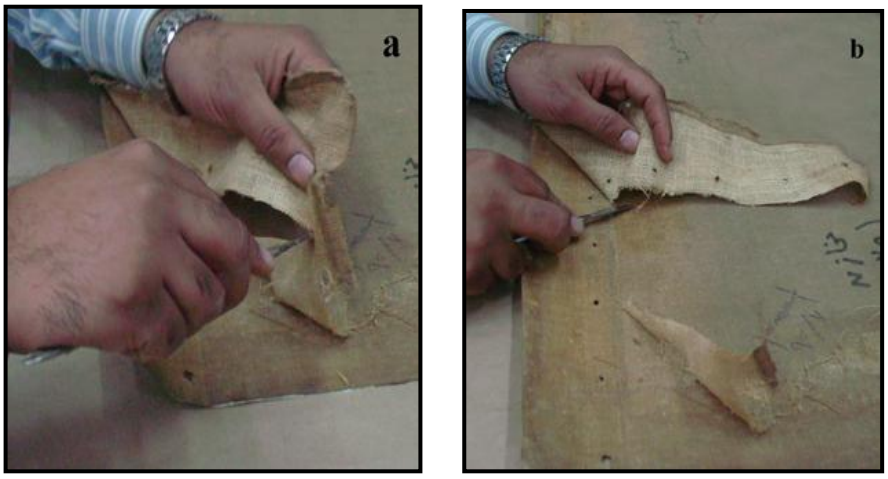

Fig. 19. Removal of the previous lining by cutting the additional support into 2-3cm, then pulling off in strips, and scalpel was used to help in the strongly adhering pieces.

Fig. 20. The use of a scalpel to remove the remains of hard adhesive glue mechanically.

Consolidation process

The consolidation was achieved by working locally in small areas approximately 15 × 15 cm. Each area was pretreated by flowing Idrocap 990 at concentration of 20% along the cleaved paint and into the cracks. Then the entire area was covered with a layer of Japanese tissue, additional polymer was applied generously through the tissue till complete saturation (Fig. 21). The area was then covered with a sheet of heavy-weight polyester film (Mylar) and gently ironed with a warm iron (the temperature about 55- 60°C) until the paint relaxed and returned to plane, Ironing should be stopped before the paint and canvas become completely dry. The oil painting is then allowed to air dry or can be placed under blotters and weights. The degree of relaxation was checked frequently by touching the surface with a finger.

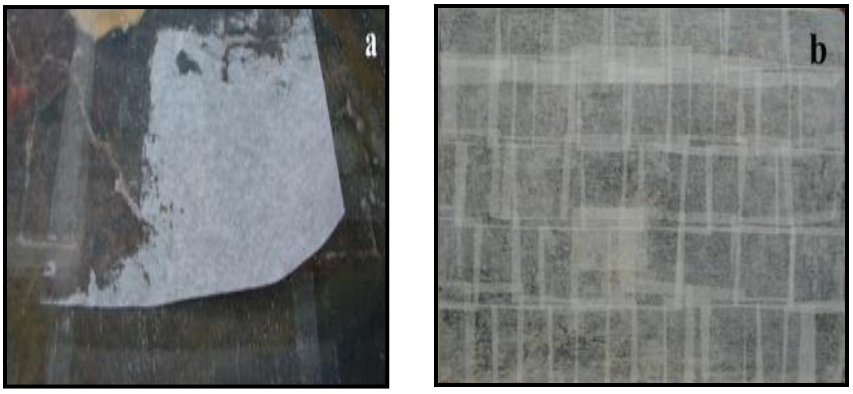

Fig. 21. The consolidation of the oil painting, by flowing Idrocap 990 locally in small areas along the cleaved paint and into the cracks. Then the entire area was covered with a layer of Japanese tissue, more of the polymer was applied generously through the tissue until it was completely saturated.

After a satisfactory degree of relaxation had been achieved, the Mylar film and the layers of Japanese tissue were carefully removed mechanically (Fig. 22). If the paint was particularly difficult to relax after usual consolidation, blotting paper and weights could be placed on the surface and left overnight. This step was not found to be necessary due to the ready response of the paint to the consolidating polymer.

Fig. 22. Removal of the layers of Japanese tissue carefully mechanically.

In the case of blind cleavage, a syringe is used to inject 20% Idrocap 990 from the canvas reverse. Before using the syringe, the area to be treated should be faced with tissue and the polymer. The consolidating polymer is injected while the facing tissue is still damp. The area can then be ironed by an electric palette knife with light pressure until dry. Once a treated area had dried, the layer of Japanese tissue was easily removed mechanically. The consolidation process can be repeated locally if the degree of relaxation is not sufficient.

In general, although consolidation can be carried out prior to cleaning, as was done in this oil painting, it is necessary to repeat the consolidation on some areas after the varnish had been removed, since an especially thick layer of varnish had initially inhibited thorough penetration of the polymer.

After the oil painting had been consolidated, the varnish layer was removed by pure ethyl alcohol (Fig. 23), the holes and fine slits of the painting were filled with putty of calcium carbonate with animal glue adhesive. After that, Inpainting and retouching of the paint layer was done with appropriate pigments to match the surrounding colors, texture and sheen of the original paint layer. The inpainting process was carried out by using Maimeri restauro ketonic resin colors which produced by binding lightfast tested pigments with ketonic resin and selected hydrocarbon solvents only; it has great reversibility and resistance to yellowing. These paints may be mixed together and thinned using the same thinners. The primary solvent for removal and thinning of the Maimeri ketonic

colors is mineral spirits (white spirits)[18] . It was applied in a thin layer of muted colors, and covered by stippling (Fig. 24).

Fig. 23. Comparison between before (left-hand side) and after removal of varnish layer (right-hand side).

Fig. 24. The inpainting process that was carried out by stippling.

After retouching, a final matte varnish layer of Soluvar picture varnish (Liquitex) was applied by spraying in vertical position, and left to dry. This varnish can be cleaned easily and removed with mineral spirits or turpentine even after aging. It dries to a clear, self-leveling, non-tacky, water resistant, hard film that is resistant to dirt retention and prevents dirt and pollutants from contacting the painted surface. This varnish stays permanently flexible, and will not crack as surface expands and contracts during temperature and humidity changes. Resists discoloring (non-yellowing, non-fogging) by humidity, heat and ultraviolet light. Contains ultraviolet light inhibitors that resist color fading by diffusing UV radiation before coming in contact with the painted surface[19] .

After drying of the varnish layer, the oil painting is fixed on the gilded frame, with small metal plates, to be present in the museum after restoration (Fig. 25).

Fig. 25. The oil painting (Scene of a Battle) the subject of the study, after completing the restoration processes.

Conclusions

The present study reports very interesting data for a better understanding of Italian Baroque painter Salvator Rosa's paintings as a whole; the methods of examinations and analyses are very important for understanding the technique and the materials used by the artist. The synthesis of the appropriate polymeric materials to be used as consolidates, coatings and adhesives in oil paintings restoration represents a possibility to encourage the use of polymer in the conservation of painting artworks exploiting their typical properties.

The choice of the best polymer to be applied on oil paintings depends on the film characteristics, as flexibility, transparency, resistance to the yellowing and reversibility. The research indicates that polyurethanes could be employed for the consolidation of aged oil painting, which belong to the field of Cultural Heritage.

Consolidation of the deteriorated oil painting by impregnation with polyurethane polymers is considered as the most promising method because of their physical and mechanical properties, and their reversibility compared with many synthetic resins. The results of the present investigation indicate that Idrocap 990 polyurethane polymer gave more improvement in strength and stiffness which helps to restore the bond between all structural elements of the oil painting, has a high stability against artificial aging processes, and safe to use

for restoration and preservation of oil paintings. The consolidation process is a suitable solution for the oil painting that was weak and had cleavages.

This material and method of consolidation is not only exclusive for the oil painting, the subject of this study, but it could be applied to other oil paintings in restoration laboratories of museums all over the world to preserve and protect the damaged and weak oil painting. The use of polymeric materials for the consolidation and protection of artworks with historical and artistic value is widely accepted, So the co-operation between conservators and chemists should be active to develop the materials and methods of restoration for the oil painting to create a number of treatment methods for applying in case of severely damaged paintings.

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تطبيق جديد لبوليمرات البولي يوريثان لتقوية لوحة زيتية تالفة للفنان سلفاتور روزا

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اللوحة الزيتية بعنوان "مشهد معركة" للفنان الإيطالى الشهير سالفاتور روزا (١٦١٥ – ١٦٧٣م)، والتى ترجع لعصر الباروك، منفذة على حامل تصوير قماشي.. اللوحة تعانى من الضعف الشديد فى طبقاتها المختلفة بالإضافة لظهور الشقوق الدقيقة والعميقة خلال طبقات التصوير.. في هذا البحث تم دراسة اللوحة بطرق الفحص والتحليل المختلفة مثل الميكروسكوب الإليكتروني الماسح، حيود الأشعة السينية، طيف الأشعة تحت الحمراء، بالإضافة للرنين النووي المغناطيسي للحصول على معلومات علمية دقيقة تساعد على إتمام عمليات الترميم والصيانة لها، إلي جانب التعرف بشكل واضح على أسلوب الفنان المصور.. وقد تبين من الدراسة أن الفنان استخدم حامل تصوير من الكتان، بينما استخدم كربونات الكالسيوم مع الغراء الحيواني لتحضير طبقة أرضية التصوير، كما تم التعرف على المركبات اللونية الأساسية التى استخدمت فى عملية التصوير بعد مزجها مع وسيط من زيت بذر الكتان.. فى هذا البحث تم اختبار ستة أنواع من بوليمرات البولي يوريثان لاختيار أفضلهم للاستخدام فى تقوية اللوحة الزيتية المختارة، وذلك بدراسة التغير فى الخواص الضوئية من قيم الألوان ومعامل الاصفرار، وقياس الخواص الميكانيكية، بالإضافة لدراسة ثبات التركيب الكيميائي، وذلك قبل وبعد التعريض لعوامل التقادم الاصطناعي. وقد ثبت من الدراسة التجريبية أن بوليمر Idrocap 990 هو الأكثر ثباتاً واستقراراً تجاه عمليات التقادم الاصطناعي. واعتماداً على الدراسات العلمية السابقة تم إجراء عمليات الترميم للوحة الزيتية المختارة، وقد تم تطبيق بوليمر Idrocap 990 لتقوية طبقات اللوحة الزيتية الضعيفة، وذلك باستخدام طرق تطبيق مختلفة لتناسب الأجزاء التى يتم تقويتها، خاصة التى تعانى من الانفصالات الظاهرة أو غير الظاهرة بين طبقات اللوحة.