PH06
INVESTIGACIÓN

Evaluation of consolidation methods on pictorial strata affected by extreme exothermic processes: comparative study and materials testing

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One of the most aggressive agents of deterioration that can affect the colors of a painting easel, is the damage caused by extreme heat. This type of alteration is manifested as blisters, extreme stiffness and loss of elasticity of pictorial materials, is extremely complicate the processing of color fixation. In this paper, the fundamental elements that come into play in these exothermic reactions are analyzed. The original paint layers performance and the consolidating materials suitability was considered too. The study methodology was divided into three main stages. First, a study of the physical-mechanical behavior of oil paintings on canvas commercial primer (used routinely by the artists) when they are subjected to extreme temperatures was performed. Later, we analyzed the types and degrees of alteration proceeded to the experimental laboratory, by comparative of different materials consolidating. Finally we proceeded to the elaboration of a specific methodological guideline, to facilitate this complex treatment.

Keywords

Adhesives | Burned paintings | Canvas | Tested materials |

Evaluación de métodos de consolidación de estratos pictóricos afectados por procesos exotérmicos extremos: estudio comparativo y testado de materiales

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Uno de los agentes de deterioro más agresivos que puede afectar a la policromía de una pintura de caballete, es el daño provocado por fuentes de calor extremo. Este tipo de alteración se manifiesta en forma de ampollas, con extrema rígidez y pérdida de elasticidad de los materiales pictóricos, que extremadamente quebradizos complican las labores de manipulación y el tratamiento de fijación del color. En este trabajo se analizan los elementos fundamentales que entran en juego en estas reacciones exotérmicas, para evaluar el comportamiento tanto de los estratos pictóricos originales, como de diferentes materiales consolidantes y su adecuación o no en el tratamiento de pinturas afectadas por esta problemática. La metodología de estudio se dividió en tres etapas fundamentales: estudio del comportamiento físico-mecánico de pinturas al óleo sobre tela de imprimación comercial, cuando se encuentran sometidos a temperaturas extremas; estudio experimental de laboratorio, comprendidos los tipos y grados de alteración, mediante el análisis comparativo de diferentes materiales consolidantes, y elaboración de unas pautas metodológicas concretas, que facilitasen este tipo de tratamientos tan complejos.

Palabras clave

Adhesivos | Lienzos | Pinturas quemadas | Testado materiales |

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INTRODUCTION

Intense heat sources, such as fires, have accounted for one of the most serious causes of deterioration with the greatest effect on heritage conservation. This research arises as a result of this type of problem and is focused on the study of the pathologies and alterations in the pictorial stratum when subjected to elevated temperatures.

The interrelation existing between temperature and the different degrees of lifting that can occur is analysed, as well as the risks which favour migration and the loss of several components of colour. Similarly, procedural protocols are established for use prior to and following the consolidation phase, such as safety tools in the treatment of these types of extremely rigid and brittle pictorial layers.

The test trials conducted in the laboratory during the testing phase have allowed for the assessment of intervention material quality, thus certifying the future stability requirements that are demanded.

OBJECTIVES AND METHODOLOGY

The objectives set out in this study have been focused on elaborating a procedural methodology which is able to safely address the intervention of these types of pathologies.

To do so, different adhesive substances and support materials were selected to carry out the fixation of colour, –conducting physical, chemical and mechanical tests– in test tubes for this purpose. These empirical studies have provided accurate data with which we can assess the effectiveness of the materials and their applicability to these types of pictorial strata.

DEGREES OF DETERIORATION IN PRONOUNCED EXOTHERMIC PROCESSES

Naturally, extreme heat near a pictorial work favours deterioration of the materials it is made of. It should be noted that there are very few studies on the thermal behaviour of the layers that form an oil painting on canvas. This is fundamentally due to the difficulty involved in measuring the resistance of each of the different materials that make up the pictorial surface.

The resistance displayed by this stratum will depend on the sum of the components that form it in each case; thus, each layer of colour will show a greater or lesser tenacity against heat (COLOMBINI; KLEITZ,

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2004: 59). Generally, organic materials will present thermal resistance values between 30 and 100ºC, while synthetic polymers vary between 150 and 200ºC (KLEITZ; VALLET, 2000: 190).

Thus, when ignition temperatures that fluctuate around 100 °C are reached, several organic compounds in the paint undergo serious thermal degradation processes including the distillation of volatile compounds and the partial oxidation of alcohol, aldehydes and acids.

Prior to reaching the melting point of the material, different degradation processes will occur such as discoloration of pigment, fragility of upper strata, softening of the pictorial layer, contraction or swelling of binding media and marked dehydration of the organic materials (BOISSONNAS, 1963: 57).

In the event that the process of pyrolysis occurs, combustion will lead to the decomposition of the pictorial materials (with the exception of glass and metal compounds). When the material reaches its softening point (Tg), plastic deformation will take place and different degrees of alteration will occur in the form of blisters. The lack of plastic memory will favour the permanence of deformations in the material, thus failing to recover its original nature. It is determined that the elasticity of a pictorial stratum will display the stretching capacity and orientation of its micromolecular chains in the direction of the force it is subjected to (BOISSONNAS, 1963: 58).

Different degrees of lifting can be established and are divided into three levels according to their seriousness. We will refer to first degree lifting when the lifting presents a cavity measuring between 0 and 0.7 millimetres (it must be pointed out that these cavities do not contain any air in their interior –a type of deformation to the pictorial layer that is poorly reversible).

Second degree blisters refer to lifting that ranges between 0.7 and 1.35 mm (presenting air in their interior and capable of affecting the ground layer) (see image 1).

Finally, third degree blisters refer to those which, in addition to containing air inside, have normally exceeded their plastic deformation limit (see image 2).

HISTORICAL EVOLUTION OF TREATMENTS: MATERIALS AND TOOLS

The evolution of treatments for burnt paintings over time has been very controversial given the wide disparity in products and methodologies

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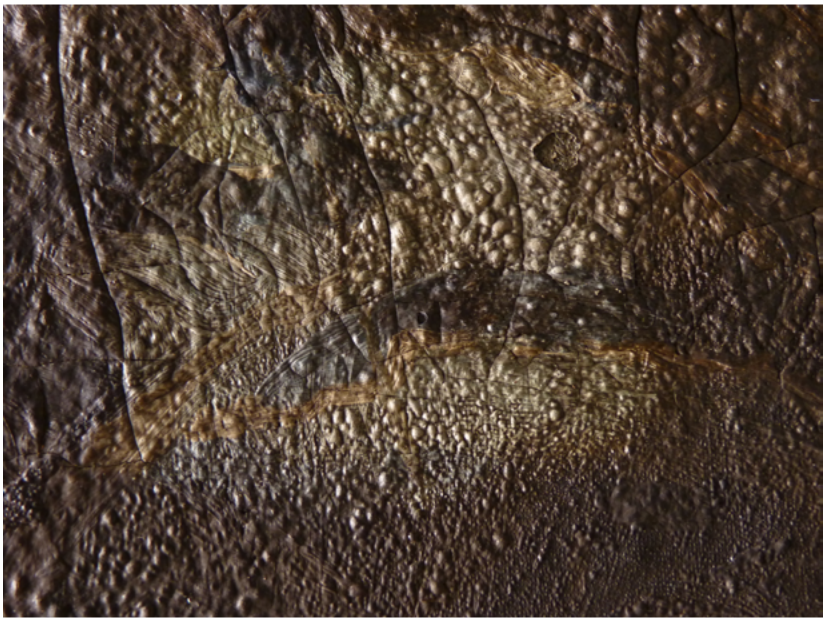

Image 1 |
Close-up under tangential light of second degree blistering of the pictorial stratum

employed. Although the early methods used on these layers are unknown, it can be said with some certainty that many works were never treated, but rather considered untreatable or irrecoverable on several occasions.

One of the major alterations exhibited by a painting that has been affected by fire is its darkening and the formation of different degrees of blistering.

Early interventions did not present an organised or consistent procedural methodology, as written sources allow us to read how the paintings were even forcefully shaken with the aim of eliminating all of the lifting that had been caused by heat. Similarly, it has also been found that the use of rough brushes (made from animal hair or metal teeth) was very common, in addition to scrapers and even razor blades; these tools were used to abrade the pictorial surface, thus eliminating the blistering and discoloured areas. Once eliminated, inpainting of the works was then normally carried out in an attempt to restore their original appearance (DUPONT, 1966: 33).

During the 17th century the physician Theodore de Mayerne recommended applying consecutive layers of fish glue to strengthen the burnt paintings. The concentration was gradually increased and it was applied on both the front and back sides of the painting. Additionally, flaxseed oil and litharge (lead oxide) were also recommended for use as colour fixatives and final varnish. After applying this oil it was suggested that the blisters be gently pressed (with fingers) in order to achieve their adhesion. The use of shellac or diluted casein was also

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Image 2 |
Third degree blistering with the maximum limit of plastic deformation

proposed as an alternative to oil as they did not cause shine like the oil did (DE MAYERNE, 1963: 65).

However, one of the most widely used materials for flattening blisters was the Italian glue-paste adhesive called colletta. Walnut oil was sometimes added to this adhesive so that it would have a greater affinity with the painting's original materials (MAYER, 1993: 533).

It has also been confirmed that formalin or mixtures of vaseline and artists' white spirit were used in a (1:1) proportion as colour softening agents to then puncture the blister and introduce painting varnish as filling material. Pressure was then applied to the area using a cloth and was maintained with an iron and controlled heat (VILLARQUIDE, 2005: 505).

Chloroform has also been utilised in the softening of these types of surfaces (GÓMEZ, 2001: 148). Its use required that the restorer had a great deal of experience as this material could end up causing extreme softening of the colour and even lead to its disintegration. It must be taken into account that the chloroform could end up leading to the regeneration of the pictorial stratum or, in other words, the materials themselves of the pictorial layer (such as Venice turpentine, Dammar varnish and rectified turpentine oil).

In this way, once the chloroform had been applied it permeated the work by osmosis and could excessively and irreversibly soften the colour. Likewise, we cannot overlook the danger that this method posed to the restorer's health.

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In 1930 the first piece of equipment designed by restorers was presented in Madrid at the ICOM Conference; it was used for easel painting interventions and was known as the hot table.

This device was a major step forward in linings but also provided great assistance to the treatment of burnt canvas paintings. The hot table consisted of a system of infrared lamps which were incorporated onto the bottom of a metallic iron; these infrared lamps were used to evenly heat the entire surface. This first prototype included a vacuum pump for achieving pressure; however, the pressure exerted was too high, thus leading to texture interferences with the lining fabrics in addition to crushing of the inlays (SCICOLONE, 2002: 107-111). This problem would not be completely rectified until 1974 when the new suction table prototype was presented at the Greenwich conference. The improvements were substantial given that the table allowed for the circulation of homogeneous air thanks to the perforations made to the metal surface (SANCHEZ ORTIZ, 2012: 125).

The first clear publication that can be found concerning interventions on burnt paintings is from 1963 by Alain Boissonnas. In this article, prior to beginning to describe the intervention process, the author stated that the only way to carry out a proper fixation of colour was by thoroughly treating each one of the blisters (BOISSONAS, 1964: 45).

From the same decade we also find similar treatments applied to works on panels, utilising the vacuum pump and heat application on the front side of the work with the help of hot air guns. In this case the blisters were reduced with the help of a rubber roller and wax-resin mixtures were used as an adhesive (BOISSONAS, 1964: 49).

EXPERIMENTAL STUDY

The research was conducted in three fundamental stages. First, a study was carried out on the pathologies presented by different oil paintings on cotton canvas that were damaged by extreme exothermic sources. Their pictorial techniques were analysed as well as the degree of deterioration suffered in the fire. Afterwards, this damage was reproduced with total accuracy on paintings of the same nature by using controlled heat sources; the objective was to obtain the same degrees of alteration.

During the second stage of the study, different adhesive and support materials were selected for use in colour fixation trials. Following this stage, an organised procedural methodology was developed for properly flattening blisters and subsequently assessing the degree of adhesion achieved.

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Protein adhesive materials were tested (6g of Technical Gelatin of pure skin® in 72mL of water), as well as polysaccharide adhesives (1g of Funori® in 150mL of water) and synthetic adhesives (a 1:1 Beva-371® and White Spirit solution). In terms of the papers or support materials, Japanese tissue paper (18g) and TNT Non-Woven Support Material-54 were analysed.

All materials were provided by CTS España. For each of the materials a total of 3 solutions were prepared under stable weather conditions of 50 % relative humidity and an average temperature of 25 ºC.

All tests were conducted at the Easel Painting and Altar Workshop at the Polytechnic University of Valencia's University Institute for Heritage Restoration.

pH measurement

This study was conducted in order to determine the range of alkalinity or acidity of the adhesive substances and to assess their suitability (or lack thereof) as strengthening materials. To do so, a DELTA pH/mV meter was used for all of the water-based adhesives, while the BEVA 371® adhesive was measured using surface pH indicator strips.

It was first observed that Funori® was the material which registered values closest to a neutral pH (7.2). Its use on works affected by fires, as far as its pH is concerned, would be acceptable. On the other hand, BEVA 371® (6.5) and Technical Gelatin® (6.3) registered more acidic ranges, although within the margins allowed.

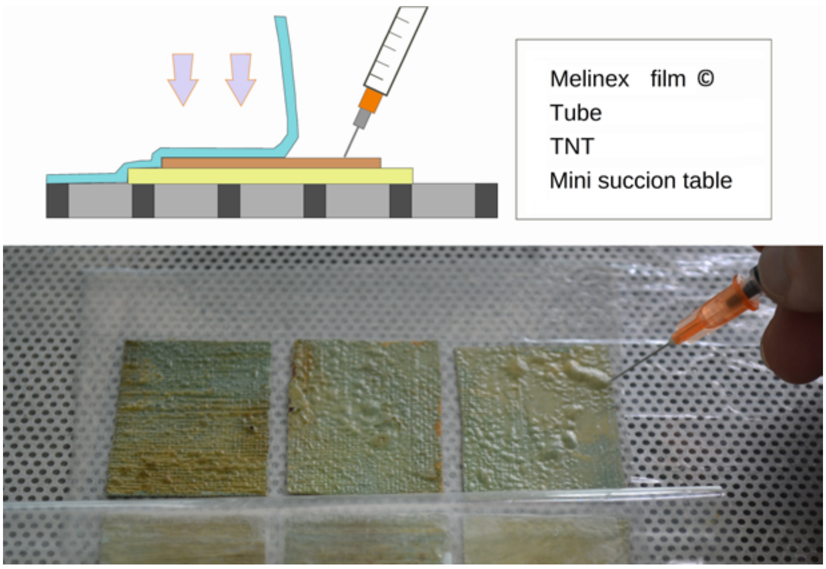

Image 3 |
Outline of the consolidation process on the mini suction table

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Analysis of hardness

The objective of the hardness test was to check the resistance of a material against a continuous, penetrating force. In this way, an adhesive that is excessively rigid could compromise the integrity of the pictorial layer if it does not adapt to the physical-mechanical necessities required by this layer.

In this case, the Shore-A measurement scale was used and the test was conducted with a TH200 Shore hardness digital durometer. Each of the adhesive mixtures were poured into non-stick containers and after their polymerisation they were cut into squares measuring 1cm on each side and 3mm thick.

From the results we observed that, within the range of measurement of 0 to 100, the synthetic adhesive BEVA 371® offered a value of resistance to penetration much lower than the rest of the materials (42.7). Meanwhile, Funori® and Technical Gelatin® registered much higher values, with (93.6) and (92.4) units of hardness, respectively. These values, however, always registered on the hardness scale marked by Shore-A regulations, thus the reason why none of the adhesives were ruled out for the next phase of testing.

Separation resistance: Quick Stick

In order to evaluate the degree of consolidation provided by each of the materials, adhesive bonds were made using the support papers (Japanese paper (18g) and TNT-54®), and each of the mixtures tested during earlier trials.

Adhesion was carried out using the mini suction table and with the aim of evenly applying pressure and temperature in a controlled manner. This way, the test tubes were gradually introduced to heat (until reaching 50°C) and suction (up to 30HP), and a Mylar Melinex film was inserted to achieve the vacuum effect.

Holes were only made to the second and third degree samples with the help of a hypodermic needle to remove the air from inside and inject the adhesive in its place. Afterwards, following elastification of the surface, the protective paper was applied to gradually eliminate colour deformations and consolidate the blisters and lifting of the stratum (see image 3).

To assess the resistance to traction and, correspondingly, the degree of maximum adhesion achieved with each of the materials, the Quick Stick test method was applied using a FORCE GAUGE-FM200 digital dynamometer.

This is an innovative study in the field of canvas painting interventions as it can be applied to other areas of research. It is based on measuring the separation resistance of a body that is subjected to continuous and gradual manual traction forces.

When the adhesion is correct it will bond in the moment it is applied to the substratum, with a high propensity to creep, which can lead to cracking.

When it is low it will allow the substrata to separate without excessive resistance (measured in Newtons).

Four centimeters of protective paper was bonded to the central part of the test tubes that were consolidated (described above) with the mini suction table. The trial began, observing how and when the paper and/or the pictorial surface started to separate. This way, we could verify the adhesive strength achieved and its surface penetration through the different strata. This study allowed us to determine the

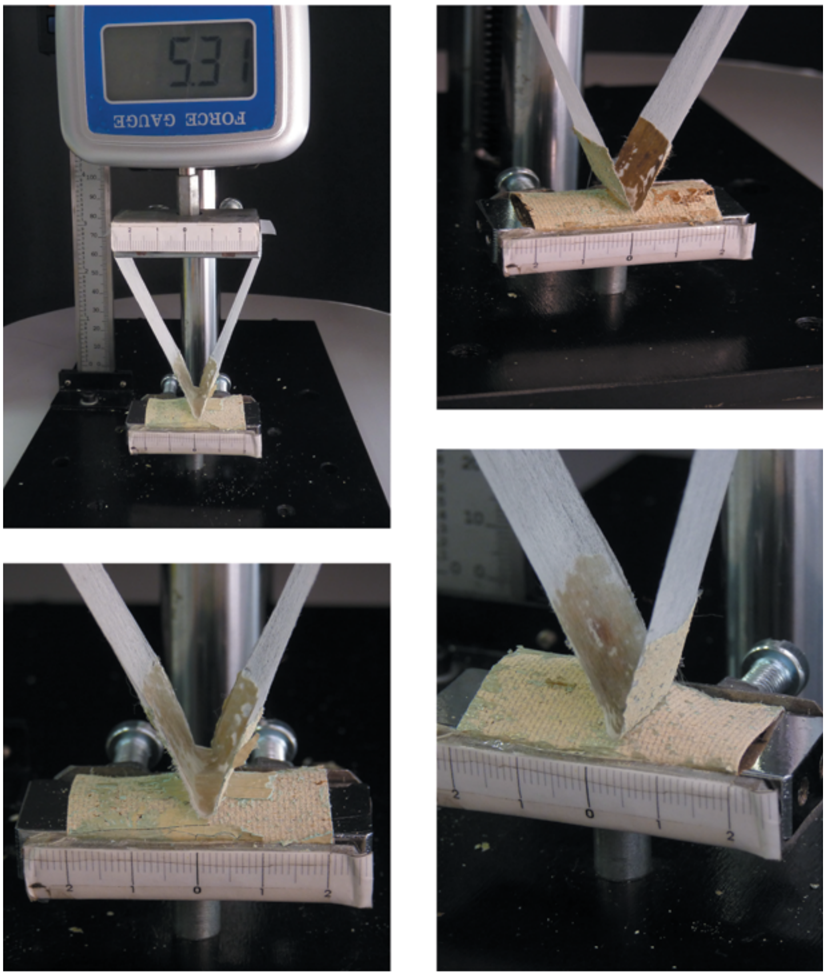

Image 4 |
Separation resistance test

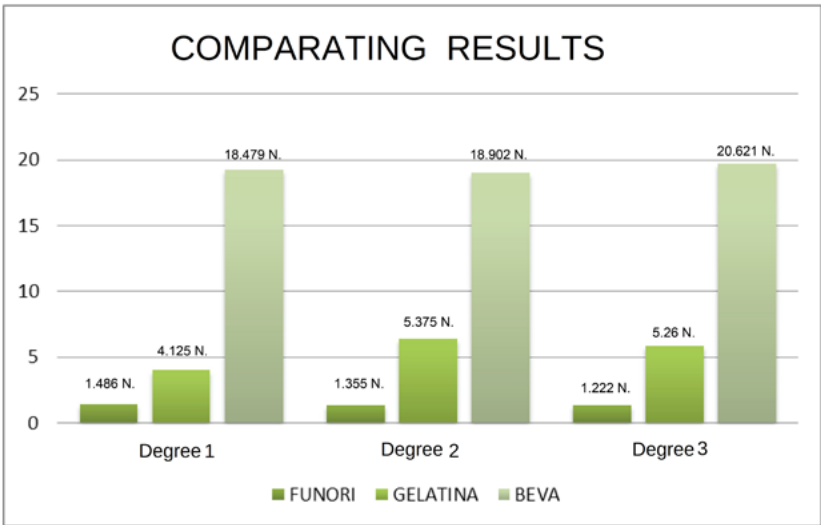

Image 5 |
Results obtained from adhesion testing

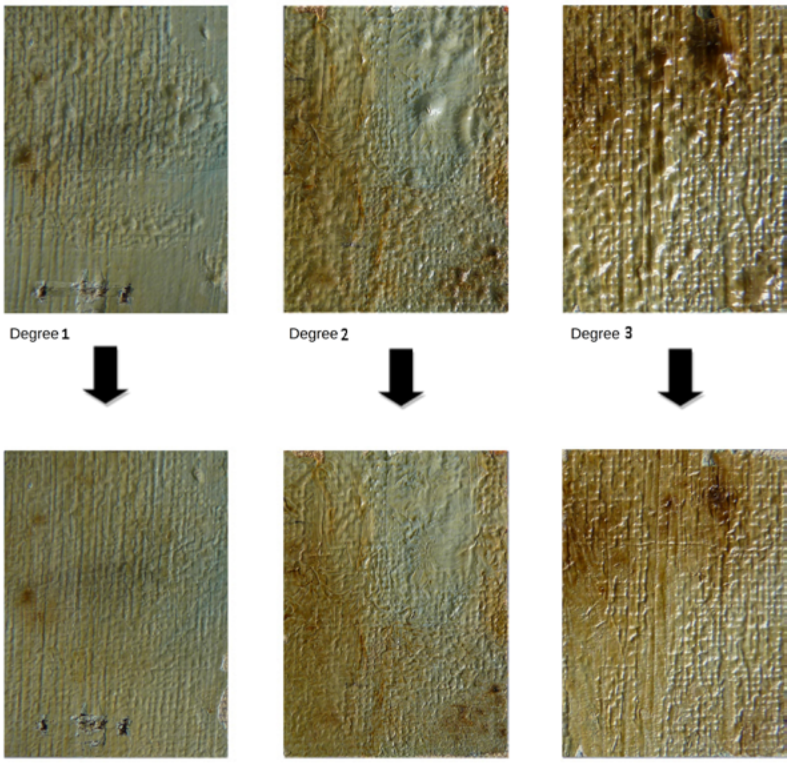

Image 6 |
Macrophotographs of the pictorial stratum before (upper images) and after the consolidation process (lower strip)

type of adhesive failure that occurred as well as the affinity between the pictorial substrata and the materials used in the intervention. It must be noted that in this trial the reversibility of the adhesive material is not induced (by means of heat or solvent), to obtain the data corresponding to maximum adhesion or maximum separation resistance (see image 4).

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After individually assessing the results for each of the adhesive materials, the large difference in the values registered must be highlighted as they did not meet all of the objectives set out at the beginning of the trial. Funori® is the adhesive substance presenting results that fall far below the necessities required by the pictorial stratum for all three degrees of alteration tested (failing to exceed 1.4 N in all cases).

Technical Gelatin® is the strengthening material with the best results in terms of consolidation and separation resistance parameters for all degrees of deterioration analysed, with average values that are not elevated (around 5.3 N). BEVA 371® is the material which presents the highest degree of adhesion and separation resistance (reaching 20.6 N), but with optimum results with regard to hardness and elasticity (see image 5).

In this case, the protein-based adhesive is the one which most evenly adjusts to the necessities manifested in the typology of the artwork being studied as well as to the adhesion standards required in the conservation and restoration of canvas paintings. The samples maintained their original rigidity and were not elasticised by the application of this substance. TNT-54® is the most suitable paper due to its high resistance, capacity to adapt and high porosity as compared to the fragility of the Japanese paper substratum (see image 6).

RESULTS AND FINAL CONCLUSIONS

> The use of suction and controlled heat with the mini suction table and a hot scraper proved favourable to the flattening of second and third degree alterations, making their application very important.

> TNT demonstrated high resistance, optimum porosity and an elevated capacity to adapt to the irregularities of the pictorial surface.

> The polysaccharide adhesive Funori® registered an appropriate pH but presented increased hardness and a capacity to bond that was more limited than the rest of the materials.

> BEVA 371® is the strengthening material with the greatest capacity to bond but presented excellent results with regard to hardness and elasticity in the test tubes.

> Although Technical Gelatin® offers a greater degree of hardness than other strengthening materials and a slightly acidic pH, it is the material which presented the best adhesion results in burnt paintings for every degree of deterioration analysed.

> It is important to emphasise that during the puncture stage prior to the protection of colour for second and third degree liftings, an incorrect methodological implementation may cause fragmentation of the blisters, thus leading to a network of craquelures that will show in the final results.

> These studies are in the developmental stage with the incorporation of elastifying materials to improve the elastic properties of the protein materials and aggregates to strengthen the adhesive capacity of the mixtures with polysaccharides.

> The growing value of the use of natural substances that are harmless to the restorer and his/her environment is promoted over more toxic and harmful substances.

> Finally, it should be indicated that the use of one adhesive mixture or another will depend on the nature and technique of the artwork and its degree of deterioration, in addition to the intervention necessities the artwork presents.

BIBLIOGRAPHY

BASSET, J. M. et al. (2005)
Diploma de especialización Profesional Universitario en Servicios de Prevención, Extinción de Incendios y Salvamento. Módulo IV: Fundamentos teóricos y técnicos. Valencia: Alfa Delga Digital S.L., 2005

BERGER, G. (1965)
A vacuum envelope for treating panel painting. *Studies in Conservation*, vol. 10, n.º 1, 1965, pp. 18-23

BOISSONNAS, A. (1963)
The treatment of fire-blistered oil painting. *Studies in Conservation*, vol. 8, n.º 2, 1963, pp. 55-66

BOISSONNAS, P. (1964)
Emploi du vacuum pour les tableaux sur Bois. *Studies in Conservation*, vol. 9, n.º 2, 1964, pp. 43-49

CIVIL, I.; MICHALSKI, S.; MURRAY, A. (2002)
Crackin the "matter paintings" of Antonio Tápies: The role of artistic intent, deterrioration and underlying mechanichal. *Thirteenth Triennial meeting ICOM-CC*. Rio de Janeiro, 22-27 September 2002. London: James & James, 2002, pp. 407-413

COLOMBINI, A.; KLEITZ, M. O. (2004)
Thermal behaviour of a painting near a tire hearth. En Mader, S. (ed.) *Proceedings of the International Congress Catastrophes and Catastrophe Management in Museums. Sarajevo, 17-21 April 2001*. Innsbruck: Tyrolean Provincial Museum, 2004, pp. 57-63

DE MAYERNE, T. (1967)
Le Manuscrit de Turquet De Mayerne: 1620-1646. Lyon: Audin Imprimeurs, 1967

DUPONT, C. (1966)
Further developments in the treatment of fire-Blistered oil Painting. *Studies in Conservation*, vol. 11, n.º 1, 1967, pp. 31-36

ERHARDT, D.: TUMOSA, C. S.; MECKLENBURG, M. F. (2000) Natural and Accelerated Thermal Aging of Oil Paint Films. En ROY, A.; SMITH, P. (eds.) *Tradition and Innovation: Advances in Conservation, Preprints of the Contributions to the Melbourne Congress, 10-14 October.* London: The International Institute for Conservation of Historic and Artistic Works, 2000, pp. 65-69

FINOZZI, A.; LODI, C.; SBURLINO, C. (2012)
Progetto Restauro: Trimestrale per la tutela dei Beni Culturali. *Fondazione Villa Fabris Supplemento*, n.º 3, al 62, 2012, p. 42

GÁLVEZ, E. (1989)
Tratamiento de pinturas quemadas: El Cristo de la Villa de Yangüas. *Revista Pátina*, n.º 4, 1989, pp. 56-61

GÓMEZ, M. (2001)
Las pinturas quemadas de la catedral de Valencia: el retablo de San Miguel del Maestro de Gabarda. Valencia: Conselleria de Cultura i Educació, Subsecretaria de Promoció Cultural, 2001

KLEITZ, M. O.; VALLET, J. M, et. al. (2000)
La prèvention des sinestres dans les aires de stockages du patrimoine: Questions sur la sensibilité Thermique des peintures de chevalet en présense d´un incendie. Marseille. 2000, pp. 189-190

MARTÍN-REY, S.; MARTÍN, J. M. (2008)
Adhesión y adhesivos en intervención de pintura sobre lienzo. Valencia: Universitat Politècnica de València, 2008

MAYER, R. (1993)
Materiales y técnicas del arte. Madrid: Akal, 1993

MCKAY, D. A. (1977)
The Treatment of Blistered Paintings. Kingston, Ontario: Queen´s University, 1977

NICOLAUS, K. (1999)
Manual de restauración de cuadros. Alemania: Konemann, 1999

PIVA, G. (2001)
L'Arte del Restauro: Il restauro dei dipinti nel sistema antico e moderno. Seccondo le oppere di Secco Suardo e del prof. R. Mancia. Milano: Ulrico Hoepli, 2001

ROS, F. (2001)
La polémica sobre los retablos de estuco en Sevilla a finales del siglo XVIII. *Laboratorio de Arte*, n.º 14, 2001, pp. 109-110

SANCHEZ ORTIZ, A. (2012)
Restauración de obras de arte: Pintura de caballete. Madrid: Akal, 2012

SCHAIBLE, V. (1993)
Il risamente del supporto e l´adesione del colore nei dipinit su tela. *O.P.D. Restauro*, n.º 5, 1993

SCHILLING, M. R., KHAJIAN, H. P.; CARSON D. M. (1997)
Fatty acid and glycerol content of lipids effect of ageing and solvent extraction on the composition of oil paints. *Techne*, 5, 1997, pp. 71- 78

ROBLES-ANDREU, A.; MARTÍN-REY, S.; CASTELL-AGUSTÍ, M. et ál. (2016)
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SCICOLONE, G. C. (2002)
Restauración de la pintura contemporánea: de las técnicas de intervención tradicionales a las nuevas metodologías. Hondaribia (Guipúzcoa): Nerea, 2002 (Arte y Restauración; 8)

STRAUB, R. E.; REESJONES, S. (1955)
There has been no previous of this method of treating fire-blistered painting, thought the hot-table has been used since its inception for attaching flaking and cupping paint. *Studies in Conservation*, vol. 2, n.º 2, 1955, pp. 55-63

SWEIDER, J. R.; SMITH, M. (2005)
Funori: Owverview of a 300-Year-Old consolidant. *Journal of the American Institute for Conservation*, 2005, pp. 117-126

TAHK, C. (1979)
The recovery of color in Scorched Oil Paint films. *Journal of the American Institute for Conservation*, vol. 19, n.º 1, pp. 25-27

THIERRY, O. (2006)
Il trattamento di tre dipinti danneggiati da un incendio nella Chiesa di Eidsvoll, Norvegia. Lugano: Salvati dale fiamme: Gli interventi su edifice e oggetti d´arte danneggiati dal fuoco. SUPSI, 6 de octubre, 2006, pp. 98-100

VILLARQUIDE, A. (2005)
La pintura sobre tela II: Alteraciones, materiales y tratamientos de restauración. San Sebastián: Nerea, 2005