Study on application methods of three adhesives used in the consolidation of contemporary paintings

Estudo de métodos de aplicação de três adesivos usados em consolidação de pinturas contemporâneas

Rosario Llamas

Instituto de Restauración del Patrimonio, Universidad Politécnica de Valencia,
Departamento de Conservación y Restauración de Bienes Culturales, Camino de Vera s/n, 46022, Valencia, España,
rllamas@crbc.upv.es

Abraham Reina

Instituto de Restauración del Patrimonio, Universidad Politécnica de Valencia,
Departamento de Conservación y Restauración de Bienes Culturales, Camino de Vera s/n, 46022, Valencia, España.

Abstract

Consolidation of contemporary paintings is a practice as complicated as delicate mainly due to the possibility of modifying the works' finishing. Conservators sometimes find limits facing these troubles because of the difficulty of applying adhesives with a paintbrush. The authors, in their attempt to give a practical and useful solution to this problem, have experimented in this work with different adhesives which are adequate for consolidation of contemporary paintings. They also have evaluated different application methods, and all of these tests were developed on poorly-bounded paintings. The study on combined methods of application was undertaken in order to compare the use of an ultrasonic atomizer with a low-pressure micro-table and an ultrasonic atomizer without a low-pressure micro-table. In this occasion, the study just wanted to analyze the deviation of colorimetric and gloss parameters for detecting if surfaces suffer aesthetic variations which may interfere with the works' concept. Conclusions finally show that it is possible to heavily consolidate poorly-bounded paintings by using an aqueous adhesive in a low concentration and an ultrasonic atomizer. The combination with a low-pressure micro-table will depend on the necessity of a punctual or general action of the adhesive.

Keywords

Contemporary paintings; Adhesives; Consolidation; New processes; Conservation.

Resumo

A consolidação de pinturas contemporâneas é uma prática tão complexa como delicada, principalmente devido à possibilidade de modificar as superfícies pictóricas. Os conservadores, encontram por vezes limitações suscitadas por este problema devido à dificuldade de aplicar adesivos com pincel. Os autores, numa tentativa de dar uma solução prática e útil a este problema, fizeram, neste trabalho, experiências com diferentes adesivos adequados à consolidação de pinturas contemporâneas. Avaliaram igualmente métodos de aplicação diferentes, tendo, todos os testes sido desenvolvidos em camadas pictóricas mal aglutinadas. O estudo com métodos de aplicação combinados foi empreendido para comparar o uso de *atomizador ultra-sónico* com baixa pressão e de *atomizador ultra-sónico* sem baixa pressão.

Nesta ponto, o estudo apenas quis analisar o desvio de cor e dos parâmetros de brilho para detectar se as superfícies teriam sofrido variações estéticas que interferissem com o conceito das obras.

As conclusões mostram que é possível consolidar fortemente camadas pictóricas mal aglutinadas utilizando um adesivo aquoso numa concentração baixa e um *atomizador ultra-sónico*. A combinação com baixa pressão dependerá da necessidade de uma acção pontual ou geral do adesivo.

Palavras-chave

Pinturas contemporâneas; Adesivos; Consolidação; Novos processos; Conservação.

■ Introduction

Contemporary artists, in view of the necessity of getting matt and textured painting surfaces [1], often obtain as a result pictorial layers affected by poorly-bounded colors, which are highly unstable against mechanical stress [2]. This can suppose an important problem for a contemporary painting, because its idea or concept can be heavily affected, and then, this can suppose its ruin: the artwork would not work anymore. But the problem goes farthest and also involves conservators' work, because unbounded colors do not allow for traditional consolidation treatment with paintbrushes and Japanese paper. If a conservator acts like this, matt paintings can easily show marks on their surface because of the product solvent, or pigment particles can just be swept. Obviously, this would suppose the destruction of an artwork, and thus, the conservator would be in trouble. As we can see, the problem with the contemporary paint is still unsolved.

All of us can remember that article by J. L. Down *et al.* from the Canadian Conservation Institute, which tried to test some poly(vinyl acetate) and acrylic adhesives used in conservation [2-3]. Since then, and mostly in the last years, investigators are focusing their efforts in testing new consolidants, and their action and behavior through accelerated ageing and UV exposure in order to assess their usability [4-5]. But what happens with the using methods? Apart from behavior, sometimes conservators also need some information about the right application methods to avoid changes in the works appearance. More than chemical interpretations, they also need to know how an adhesive acts when it is applied on a contemporary paint film: does it stay where it has been applied? How far does it penetrate? Does it consolidate seriously unbound colors? How many applications does it need to be effective? How does it adhere to color particles? After this investigation we will try to solve some of these questions and give practical information concerning the consolidation of contemporary paint films.

The chosen consolidants for this study have been three different adhesives: Funori (seaweed), Gelvatol (polyvinyl alcohol) and Acril 33 (acrylic resin in aqueous dispersion). Funori was chosen for its capability to consolidate offering a matt surface. This consolidant, already named in articles dating from 1935 [6], also has excellent ageing properties and has shown a good photo-oxidative

performance during tests [7]. Gelvatol was chosen because it has also showed good properties and behavior through time, and can offer matt surfaces after use. And finally, Acril 33 was selected because of its affinity to paint film made of acrylic.

■ Experimental Procedure

■ ■ Specimen preparation

For this study, commercial canvases were chosen as a base, just as usually contemporary artists do for creating their paintings, and its main features are: size 46 x 38 cm²; textile composition based in cotton (60 %), polyester (26 %) and viscose (14 %); density of 12 x 12 threads per centimeter; priming based in animal glue and ground layer made of an alquidic agent for oil colors.

Blue paint was also prepared in order to be applied over these canvases. After checking different concentrations, proportions, grades of cohesion, mattness, etc., a mixture of 7 % of acrylic Liquitex (cobalt blue), 93 % of pigment blue "Microgiraltn" (num. 93) and deionized water was made for painting the surfaces. Several layers were applied to obtain sufficient thickness, and the application tried to avoid marks by the paintbrush.

■ ■ Adhesives preparation

The three adhesives chosen for this study were aqueous, as the atomizer requires. So, they were dissolved in deionized water in different concentrations (by weight) depending on their nature (Table 1). Acrylic and vinyl adhesives were prepared in lower concentrations because they can easily produce glossy surfaces and generate viscous solutions which are hard to atomize. Funori concentration however, can be slightly raised the and still be atomized, keeping mattness.

Acril 33 and Gelvatol aqueous dissolutions were easily made. To elaborate the four Funori mixtures it was necessary to create a main solution: the alga (1 g) was added to 120 ml of deionized water and was left hydrating for 24 hours. After this, the mixture was stirred at 1200 rpm and 40 °C during 60 min and then filtered. Finally, in order to avoid a fast biological degradation, a drop of biocide (Biotin N, Tributyltin

Table 1 Concentrations of consolidant solutions (by weight).

Adhesive	Concentration %			
Acril 33	0.5	1.5	2.5	5
Gelvaton	0.5	1.5	2.5	3
Funori	0.2	2	4	6

Naphthenate and Quaternary Ammonium Salts) was added to the solution.

■ ■ Adhesives application and consolidation tests

In order to find a good method to apply adhesives to fix the unbound pigments, three ways to proceed were performed: atomizer (model Becker Preservotec AGS 2000), atomizer with low pressure micro-table and, finally, paintbrush and Japanese paper with low pressure micro-table. Before starting the applications, a template in white card was elaborated to guarantee an organized procedure with every specimen. The atmospheric parameters during the experiments, measured with a Thermo-hygrometer TESTO 608-H1, were 65-70 % RH and 28-30 °C.

To homogenize the procedure with consolidants in the machine, the way to apply adhesives was as follows: the atomizer hose was positioned in the center of every square at 10 cm of distance. Then, it was switched on medium power for every square-concentration except in the case of higher proportions (Acril 33 5 %, Gelvatol 3 %, Funori 6 %), when it required to be used in the 'maximum' position, to allow the generation of vapor (Figure 1). The atomizer was working for 60 seconds over the painting and then stopped for 60 seconds more to let it dry. This process was repeated until achieving consolidation, which was tested with a swab by turning it and rubbing softly. In the cases where the low pressure micro-table was used (model CTS NSD 11), its micro-perforated plate was placed under the canvas and the suction was set at 4999.57 Pa (37.5 mmHg).

In the case of applications with paintbrush, Japanese paper and low pressure micro-table, application was easier. Adhesives were used after switching on the suction. When the surface was dry, the level of consolidation was tested in the same way as before. The process was repeated until getting a consolidated surface.

In order to know how these consolidants can change the paintings appearance, mainly by increasing shade and gloss, a chromatic measurement of the surface was performed before and after with a Spectrophotometer Minolta 2500d (measurement area of 3 mm, illuminant D65, 10° measurement geometry). Three color and gloss measurements were carried out for each sample (Tables 2-4).

Finally, a microscopic surface analysis was accomplished. This analysis aimed at verifying how the adhesives' particles behave and are deposited on the original paintings and therefore, at better understanding how consolidants may change the paintings appearance. To observe surfaces, a StereoZoom Microscope Leica S8APO was used at 80x.

Fig. 1 Atomizer working during the experimental work: steam generation and ejection. Canvases were placed over the low pressure micro-table.

Table 2 Total color difference (E increase in SCE/SCI) and gloss difference after consolidation (Acril 33).

Test	Name	$\Delta E^*(SCE/100)$	$\Delta E^*(SCI/100)$	ΔG
1	1Acril 0.5 % atomizer	2.39	2.36	0.03
2	2Acril 1.5 % atomizer	1.24	1.23	0.00
3	3Acril 2.5 % atomizer	1.02	1.00	0.02
4	4Acril 5 % atomizer	1.94	1.94	0.00
5	5Acril 0.5 % atomizer + LPMT	2.51	2.50	0.01
6	6Acril 1.5 % atomizer + LPMT	3.01	3.02	0.01
7	7Acril 2.5 % atomizer + LPMT	3.65	3.64	0.01
8	8Acril 5 % atomizer + LPMT	0.67	0.67	0.00
9	9Acril 0.5 % paintbrush + LPMT	1.89	1.89	0.00
10	10Acril 1.5 % paintbrush + LPMT	2.12	2.12	0.00
11	11Acril 2.5 % paintbrush + LPMT	2.38	2.38	0.00
12	12Acril 5 % paintbrush + LPMT	4.44	4.45	0.02

Table 3 Total color difference (E increase in SCE/SCI) and gloss difference after consolidation (Funori).

Test	Name	$\Delta E^*(SCE/100)$	$\Delta E^*(SCI/100)$	ΔG
13	1Funori 0.2 % atomizer	1.90	1.88	0.03
14	2Funori 2 % atomizer	1.52	1.53	0.00
15	3Funori 4 % atomizer	1.28	1.29	0.00
16	4Funori 6 % atomizer	0.51	0.51	0.00
17	5Funori 0.2 % atomizer + LPMT	1.20	1.20	0.01
18	6Funori 2 % atomizer + LPMT	1.21	1.20	0.01
19	7Funori 4 % atomizer + LPMT	1.65	1.65	0.00
20	8Funori 6 % atomizer + LPMT	1.74	1.73	0.01
21	9Funori 0.2 % paintbrush + LPMT	0.81	0.81	0.00
22	10Funori 2 % paintbrush + LPMT	0.54	0.56	0.01
23	11Funori 4 % paintbrush + LPMT	0.55	0.54	0.01
24	12Funori 6 % paintbrush + LPMT	0.70	0.70	0.00

Results and Discussion

Specimen preparation

After numerous years studying the work of Spanish contemporary artists, the choosing of materials to accomplish this analysis was easy. As described earlier,

several tests of concentrations of pigment and acrylic were prepared before deciding which one was the most suitable. The definitive concentration was not easy to find (Figure 2), because even using a good binder or acrylic (just as Liquitex is) the color layer can result defective if the mixture is not made in a correct proportion. When a high proportion of acrylic is used (10-15 % onwards),

Table 4 Total color difference (E increase in SCE/SCI) and gloss difference after consolidation (Gelvatol).

Test	Name	$\Delta E^*(SCE/100)$	$\Delta E^*(SCI/100)$	ΔG
25	1Gelvatol 0.5 % atomizer	3.42	3.44	0.02
26	2Gelvatol 1.5 % atomizer	5.07	5.09	0.02
27	3Gelvatol 2.5 % atomizer	5.69	5.72	0.03
28	4Gelvatol 3 % atomizer	2.30	2.30	0.01
29	5Gelvatol 0.5 % atomizer + LPMT	2.15	2.16	0.01
30	6Gelvatol 1.5 % atomizer + LPMT	4.86	4.88	0.02
31	7Gelvatol 2.5 % atomizer + LPMT	5.98	6.01	0.03
32	8Gelvatol 3 % atomizer + LPMT	2.69	2.70	0.00
33	9Gelvatol 0.5 % paintbrush + LPMT	0.97	0.98	0.01
34	10Gelvatol 1.5 % paintbrush + LPMT	2.53	2.54	0.01
35	11Gelvatol 2.5 % paintbrush + LPMT	3.07	3.08	0.01
36	12Gelvatol 3 % paintbrush + LPMT	2.35	2.37	0.02

excessive gloss in the resulting painting is obtained. But if this proportion is excessively short, then the color layer detaches and falls.

■ ■ Adhesives preparation

Acril 33 was the most easy to utilize adhesive of the three because it is ready to use. Gelvatol required time to hydrate and to allow its dissolution, or to be prepared

by using a stirrer and warming the water at the same time (this way, the adhesive can be ready in 1.5-2 hours).

Finally, although the main dissolution of Funori can be prepared in different ways [6], the proportion 1 g per 120 ml of water was chosen. After this, it was warmed (40 °C) and stirred during 60 min (Figure 3). Starting from this point and after filtering, the four dissolutions were elaborated. It is also recommended to add a drop of biocide to the solutions and to conserve them on the

Fig. 2 Specimen made for the experimental work: a) macroscopical and b) microscopical appearance.

Fig. 3 Intensive stirring of the Funori dissolution at 1200 rpm.

fridge because Funori solutions easily suffer degradation. Otherwise, they just can be conserved for two or three days.

■ ■ Adhesives application and consolidation tests

The limits of concentrations (maximums) were finally fixed by the atomizer, since it basically is made for vaporizing water. The numbers of necessary adhesive layers to achieve the painting consolidation are provided in Table 5.

After adhesives have been applied it is possible to show how synthetics need a lower number of layers

to completely consolidate the painting and, on the contrary, how the seaweed is not able to consolidate an unconsolidated painting if it is prepared in a low concentration (0.2 %). It is also possible to check how paintbrush applications need an important lower number of layers to consolidate (maximum four for Acril 33, nine for Funori and five for Gelvatol), but on the other hand, it is the method which shows the worst aesthetic results as it leaves marked rings on the painting.

It seems that synthetic adhesives need fewer layers to consolidate by using a low pressure micro-table, although this way reduces the consolidated area because the suction attracts the vapor (more or less, 3 cm diameter). Although Acril 33 does not show a bad behavior, the consolidative product that has shown better optical results has been Funori, since it does not change the painting appearance. So, it is possible to fix an unconsolidated pictorial layer by applying 14-20 layers of Funori at 6-4 % respectively with an atomizer. All of the adhesives keep mattness. The final specimen appearance is shown in Figure 4.

In general, for synthetics, the surfaces treated without low pressure micro-table receive higher amounts of product because of a lower focalization of the steam jet, and those treated with a low pressure micro-table show marks in the center, corresponding to the point where

Table 5 Number of layers applied over the painting for every adhesive and proportion

Percentage	Atomizer	Atomizer & Low pressure micro-table	Paintbrush, Japanese paper & Low pressure micro-table
Acril 33 0.5 %	25	30	4
Acril 33 1.5 %	15	15	3
Acril 33 2.5 %	14	12	3
Acril 33 5 %	12	12	2
Funori 0.2 %	30 (not consolidated)	30 (not consolidated)	9
Funori 2 %	25	25	6
Funori 4 %	20	20	5-6
Funori 6 %	14	14	3
Gelvatol 0.5 %	30	30	5
Gelvatol 1.5 %	15	10	3
Gelvatol 2.5 %	15	10	2
Gelvatol 3 %	22	13	1

CONCENTRATIONS (PERCENTAGE)				
ATOMIZER	ACRIL 33 - 0,5% FUNORI - 0,2% GELVATOL - 0,5%	ACRIL 33 - 1,5% FUNORI - 2% GELVATOL - 1,5%	ACRIL 33 - 2,5% FUNORI - 4% GELVATOL - 2,5%	ACRIL 33 - 5% FUNORI - 6% GELVATOL - 3%
ATOMIZER & LOW PRESURE M.T.	ACRIL 33 - 0,5% FUNORI - 0,2% GELVATOL - 0,5%	ACRIL 33 - 1,5% FUNORI - 2% GELVATOL - 1,5%	ACRIL 33 - 2,5% FUNORI - 4% GELVATOL - 2,5%	ACRIL 33 - 5% FUNORI - 6% GELVATOL - 3%
PAINTBRUSH	ACRIL 33 - 0,5% FUNORI - 0,2% GELVATOL - 0,5%	ACRIL 33 - 1,5% FUNORI - 2% GELVATOL - 1,5%	ACRIL 33 - 2,5% FUNORI - 4% GELVATOL - 2,5%	ACRIL 33 - 5% FUNORI - 6% GELVATOL - 3%

a)

b)

c)

d)

Fig. 4 Specimen appearance after experimental work: a) scheme; b) Acril 33; c) Funori and d) Gelvatol specimens.

the atomizer was focused. The applications at lower concentrations become ineffectual because they need excessive repetitions (more than 30).

After observing surfaces with a stereo microscope, the adhesives deposition can be interpreted. It seems Funori possesses reduced particles and penetrates more easily, since it is not possible to find any difference on the surface before and after consolidation (Figure 5). In contrast, regions treated with Acril 33 and Gelvatol show little pearls deposited on the surface (Figure 6).

■ ■ Colorimetric tests

After checking the results obtained in the analysis undertaken on the specimens it is possible to observe how all the adhesives tested in the study produce chromatic changes on the paint films. While Funori produces a minimum influence in the original chromatic features, Gelvatol in the same conditions causes a change almost five times higher (E^* increase up to 5.98). In the same way it is possible to observe in the numbers how adhesives used in high concentrations (Acril 33 at 5 %, Funori at 6 % and Gelvatol at 3 %) are vaporized with a lower flow and

Fig. 5 Image of the surface under the microscope before (a) and after (b) consolidation using Funori. Morphological structure is almost the same before and after applying the adhesive. Adhesive accumulation is not observed in the whole surface.

Fig. 6 Surface appearance under the microscope after using Acril 33 (a and b) and Gelvatol (c and d). Note that pearl adhesives in surface after consolidation are bigger and more numerous than in unconsolidated ones. Adhesives also show punctual accumulation of particles.

thus changes in color are lower, breaking the logical rising tendency.

If we observe the influence of the application methods in relation with chromatic changes, it seems like using or not using a low pressure micro-table does not generate considerable changes except with Acril 33, where it is possible to perceive them. In relation with the operations with a paintbrush and in spite of the important marks they leave, both Funori and Gelvatol give lower chromatic changes if we compare with processes where an atomizer with or without low pressure micro-table was used. This tendency does not occur for Acril 33.

If we finally analyze the influence of adhesives' gloss on paint films we realize that it is almost inappreciable, because the maximum change is 0.03. The average on gloss increase in the case of Acril 33 and Funori is 0.00, while in the case of Gelvatol is 0.02.

■ Conclusions

Studies on consolidations and methods of application are necessary in order to guarantee the conservation of contemporary and non-traditional painting. In this situation, it is the conservator who faces interventions and decides about how to apply a consolidant. Thus, it was necessary to find a way to apply all these adhesives that continuously are being studied and also to give concrete directives to solve the concrete problem of matt surfaces.

After carrying out this study, it has been possible to show how it is achievable to consolidate contemporary matt paintings without affecting their aesthetic appearance, and the way and instrumentation to accomplish it. To attain this objective it is necessary to bear in mind that an atomizer is not able to vaporize high concentrations of adhesives and that it is necessary to repeat several times until getting the particles well bonded. In some occasions a higher power of the atomizer would be desirable, but it is not recommended to eject dense amounts of steam because the painting can become marked.

It has also been observed how synthetic adhesives consolidate faster than the alga, but using them we run the risk of changing the color shade. Gelvatol constitutes an obvious example, and the use of low pressure micro-table enhances this effect by focusing the steam in a point. It seems that the more slowly the adhesive works

(necessity of higher number of layers), the less it affects works' appearance.

The differences between applying adhesives with a paintbrush or with an atomizer have also been shown in this study. In the areas where a paintbrush was used, results were the same: a painting heavily marked by the adhesives. The effects of using a low-pressure micro table were also obvious: when a conservator wants to concentrate the action of the atomizer because of a punctual damage, it is advisable to combine both tools to avoid impregnation of surrounding surface. In the opposite situation, if we do without an atomizer, we can impregnate a wider area.

In relation to colorimetric matters, it has been possible to check that gloss does not increase after consolidation, and in spite of all adhesives generating chromatic changes, the influence of Funori is almost imperceptible.

Although adhesives were selected according previous studies of ageing and behavior, further research will perform accelerated ageing over the consolidated paints in order to observe how adhesives behave on them in terms of chromatic variations and finishing features.

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■ Materials

Cotton canvases: Manufactured by Lienzos Levante – Artículos para Bellas Artes, Carretera Cocentaina km. 144, Muro Alcoy, Alicante, Spain (Tel.: 965530251 / e-mail: lienzos_1@infonegocio.com); and purchased by Viguer S.L. – Material para Bellas Artes, Camino de Vera, 46071 Valencia, Spain (Tel.: 00 34 963 919 054 / e-mail: info@viguer.com).

Pigment Blue Microgiralatin num. 93 and Cobalt Blue "Liquitex": purchased by Viguer S.L. – Material para Bellas Artes, Camino de Vera, 46071 Valencia, Spain (Tel.: 00 34 963 919 054 / e-mail: info@viguer.com).

Acril 33, Gelvatol, Funori and Biotin: Purchased by CTS España Productos y Equipos para la Restauración S.L., C/Monturiol, 9, Polígono Industrial San Marcos, Getafe, Madrid, Spain (Tel. +34 916011640 / e-mail: cts.espana@ctseurope.com)

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