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Consolidation and Adhesion of Pictorial Layers on a Stone Substrate. The Study Case of the Virgin with the Child from Palazzo Madama, in Turin

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Abstract: The study and the restoration of a polychrome limestone statue representing the Virgin with the Child, from Palazzo Madama in Turin (NW Italy) offered interesting conservation issue related to the polychromy on stone. To preserve the pictorial layers, it was necessary to re-establish the cohesion among the different polychrome layers (original and repainted) and the adhesion between polychrome film and the stone substrate. Particular attention was paid to the choice of intervention materials, selected through a preliminary survey of the scientific literature, and then verified by laboratory tests (tape test, colorimetric test, and permeability test). The most suitable product should to be able to penetrate porosity, to consolidate the layers, to make the pictorial film adhere with the stone surface, and to avoid changes in the colour and in the permeability. The material chosen also had to ensure compatibility with the cleaning method that could only take place after the consolidation of the pictorial layers due to the problematic state of preservation. A range of products, characterised by their small particle size and low viscosity, was tested, and a micro-acrylic resin was selected and successfully applied on the polychromy of the sculpture.

Keywords: polychromy; polychrome stone statue; adhesion and cohesion products; conservation of pictorial films on stone

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1. Introduction

A polychrome stone consists of a complex and heterogeneous system: the stone substrate and one or more pictorial layers covering the stone. The first is inorganic, porous, transpiring, and hydrophilic; the second ones are less transpiring, partially organic (dyes and several types of binder media), and partially inorganic (mineral pigments). The approach to the consolidation and the adhesion of the pictorial layers covering stone sculptures, therefore, is not uniquely defined.

The object of this study is a polychrome limestone statue representing the Virgin with the Child, from Palazzo Madama in Turin (Figure 1) [1–3]. The work of art has been the subject of a thesis work [4] University of Turin in collaboration with the Foundation Centro Conservazione e Restauro "La Venaria Reale", during the academic year 2017–2018.

Based on comparisons [5–7], the bodies of Mary and Jesus can be attributed to the French style of the 14th century. The head of the Virgin is stylistically similar to some French pieces of the 15th century [8]. The head of the Child is a plaster cast hypothetically made between the 19th and the 20th century, most likely to replace the original missing piece, and it has not been painted. The bodies of the Virgin and the Child are carved in a fine-grained, carbonate sedimentary rock of uncertain provenance, that can be defined as biopelsparite as shown by analysing some samples of the stone under an optical microscope in transmitted polarised light. Mary's head is composed of a carbonate lithotype, a different, more porous and finer-grained limestone. A sample of the the lithotype was observed under an optical microscope and a scanning electron microscope and analysed with an EDX probe. The statue is covered by numerous fragments of pictorial layers, composed of mineral pigments, dyes, and metallic foils characterised by SEM-EDX and FT-IR analyses. The identified inorganic pigments are white lead, gypsum, lead-tin yellow, yellow, brown and red ochre, minium, cinnabar, copper resinate, a different type of a copper-based pigment (verdigris or malachite or chrysocolla), azurite. The analyses also revealed the presence of indigo dye, a red dye and gold and silver foils. For some of the pigments an oil was identified as the binder medium, while in other cases it was no possible to identify the binder by FT-IR analysis. In these cases, FT-IR analyses only revealed the presence of oxalates, together with the pigments. This data led to the hypothesis that the painting technique consisted in a lean tempera (using gums, egg white, calcium dairy or animal glue as binder).

(**a**) (**b**)

Figure 1. The Virgin with the Child from Palazzo Madama in Turin, before (**a**) and after (**b**) the restoration.

Some constituent elements of the pictorial layers are altered or degraded. The presence of oxalates is perhaps due to the hydrolysis of the proteins which compose the binder of some pictorial layers and the consequent interaction of the resulting free fatty acids with metal ions from the pigments, the substrate or the environment [9,10]. The siccative oil is subjected to oxidation, cross-linking and depolymerisation, resulting in the formation of by-products [9,11,12] and loss of cohesion and adhesion. Among the by-products there are groups of free fatty acids, which bind to metal cations coming from the atmosphere or pigments or even from the stone substrate, producing metal soaps [12–14], detected by SEM-EDS analysis. They are subjected to phase changes, resulting in migrations and re-crystallisations within the polychrome layers or in one of the interfaces, forming translucent masses [12,15–17] and causing the formation of bumps on the surface. The analyses revealed the presence of sulphates, probably resulting from the transformation of carbonates (from the stone material, azurite and malachite) by the atmospheric particulate matter and humidity [18]. While the thermo-hygrometric parameters vary, these sulphates are subjected to crystallisation-solubilisation cycles, causing mechanical tensions, which lead to the embrittlement of the pictorial films. Cinnabar is altered in some points, probably due to the photo-oxidation or the interaction with the white lead or with the carbonate of the stone substrate [19,20]. Malachite also is altered, perhaps due to the interaction with soluble salts [20,21]. Finally, the presence of AgCl in silver foils is probably due to chlorides from the atmosphere [22]. The severe state of decohesion and loss of adhesion, required a consolidation and adhesion intervention, since the control of the thermohygrometric parameters was not enough to conserve them.

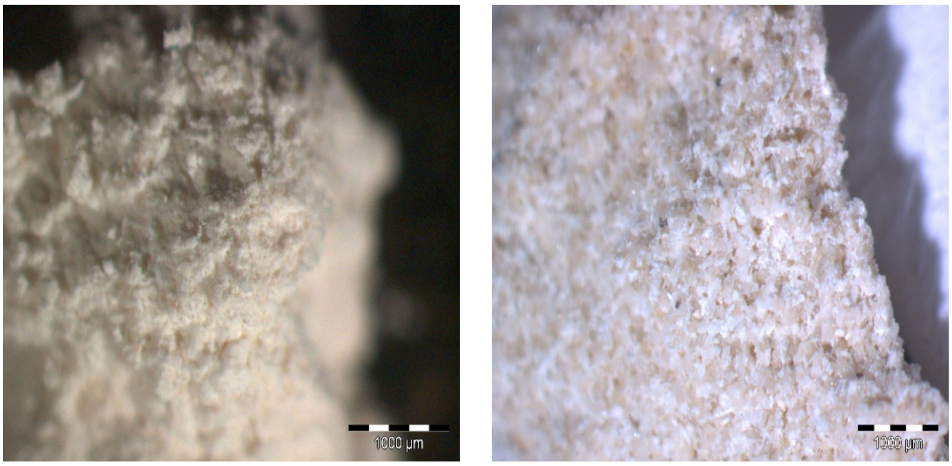
2. Materials and Methods

To select the most suitable restoration material for this case study, organic (synthetic and natural) and inorganic products were selected on the basis of the evaluation of their characteristics through a bibliographic research and then their testing on mock-ups as representative as possible of the stone-pictorial layers system found for the Virgin with the Child. The tested products are listed in Table 1.

Table 1. Tested products.

Synthetic Organic Resins	Natural Organic Resins	Inorganic Products
25% and 50% Acril ME® (by C.T.S.) [23] in demineralised water and 10% ethanol	1% and 3% Jun Funori (by Lascaux Colours & Restauro) in demineralised water [24–29]	2% and 5% Ammonium oxalate (by Sinopia) in demineralised water [30,31]
100% Acrylmat (by AN.T.A.RES) [23]	rabbit skin glue (by C.T.S.) in a ratio of 1:14 in water [24,25]	100% Nanolime CaLoSiL® E25 (by IBZ-Salzchemie GmbH & Co. KG) [32]
8% and 16% Dispersion® K52 (by Kremer Pigmente) in demineralised water [33–35]	sturgeon glue (by AN.T.A.RES) in a ratio of 1:20 in water [25]	-
33% and 50% Micral-Primal WS-24® (by Kremer Pigmente) in demineralised water	-	-
5% and 10% Microacril® CV40 (by Chem Spec) in demineralised water [36]	-	-
3% and 10% Aquazol® 200 (by Polymer Chemistry Innovations) in demineralised water and 10% ethanol [25,37–40]	-	-
100% Fluoline® HY (by C.T.S.) [41]	-	-
10% and 20% Regalrez® 1126 (by C.T.S.) in ligroin [24,42]	-	-
2% and 4% Tylose® MH 300p (by C.T.S.) in demineralised water [37]	-	-

Blocks (5 cm × 5 cm × 1 cm) were prepared with lime putty and limestone dust in a ratio of 1:3. Vinci limestone powder was selected as an aggregate: it is entirely composed of calcium carbonate and was sieved to select aggregates with ≤200–300 μm^3 dimensions (Figure 2). A plaster rasp was used to imitate the tooth chisel processing, obtaining a material which was similar to the constituting stone of the bodies of the Virgin and the Child, from a chemical and morphological point of view, as verified by an optical microscope. Since the polychrome stratigraphy of the work of art is very complex and extremely heter-ogeneous, a simplification was implemented to realise the mock-ups, even though in our opinion their representativeness was not compromised. Therefore, rather than reproducing all the layers of each area of the sculpture, only two pictorial layers were prepared. One was composed of red ochre, white lead and siccative oil (linseed oil), the other consisted of yellow ochre, white lead, and animal glue. The two pictorial layers were spread by brush on sheets of Melinex®; once dried, they were peeled off and subjected to artificial aging. During the present case study, the artificial aging in the stove lasted twenty-two days: for eleven days the temperature was kept at 60 °C and then at 110 °C for another eleven days. Following this treatment, it was possible to observe a notable stiffening of the pictorial layers and a slight variation in the colours.



(**a**) (**b**)

Figure 2. (**a**) One of the mortar samples seen under the optical microscope, with 25× magnification. (**b**) Sample of lithotype from the base of the bodies of the Virgin and the Child, seen under the optical microscope, with 25× magnification.

The adhesive power, which is considered to be the most important requirement in this case study, was evaluated with tape tests.

Each product tested was applied on a mock-up composed by the block representing the lithotype, covered by an oil painting layer and, on top, one tempera layer, both laid in fragments. The tested products were applied by syringe, allowing them to penetrate between the layers (Figure 3). The effectiveness of the organic resins was evaluated three to four days after the first application; in the case of a visible inefficacy, the product was applied a second time. Inorganic consolidants were applied four to six times. Regarding the case of nanolime, the tape test was performed thirty days after its application. Regarding each product to be tested, three pieces of Scotch® 3M were applied in three different points on the surface of each sample and then de-attached. After this, the average weight difference between the piece of tape after and before the application was calculated, using an Acculab ALC-210.4 analytical balance (Acculab, New York, NY, USA), with readability 0.1 mg. The lower the resulting value, the greater the adhesive strength of the product. The mock-ups were photographed before and after the test (Table A1, Appendix A), to see and record which layers adhered and, consequently, to evaluate the penetration capacity of the products among the different interfaces.

(a)

(b)

Figure 3. (**a**) Application of a resin upon a sample. (**b**) After the application of the product, on each specimen a weight was placed, with the interposition of a Melinex® sheet, to increase the adhesion between the layers.

The products resulting with a satisfactory adhesion strength were then subjected to the colorimetric test. The Italian recommendation NorMaL 43/93 defines the colorimetric coordinates collection on opaque surfaces of stone materials which are subjected to alterations and conservative treatments. According to NorMaL 43/93 it is possible to perform a quantitative measurement of the colour variation by detecting the colorimetric coordinates before and after the application of the product. During the present case study, a Konica-Minolta CM-700d colorimeter (Tokyo Metropolis, Japan) was used, which was equipped with a pulsed xenon lamp and an integrating sphere for diffused illumination of the sample (geometry d/8, illuminant D65, measurement conditions SCI + SCE, measurement step 10 nm, spectral range 400–700 nm). The acquisitions were performed on an oil painting film (prepared as above described). Each product was applied with a brush in a single coat. After drying, three colorimetric measurements of three distinct points were conducted for each sample.

Finally, the most suitable product must not form a water vapour impermeable film. To perform a water vapour permeability test, reference was made to the European standard EN ISO 12572 (June 2001 edition), which describes a method for determining the hygroscopic permeance of building products and materials in an environment characterised by constant temperature and relative humidity. The test was performed on samples consisting of a waterproof box containing water, with an opening, entirely covered by a mortar block (prepared as already described). Each product to be tested was applied in two layers by brush on the surface of three blocks, trying to obtain a uniform and similar application for all mock-ups. Due to the different partial pressure of the water vapour between the box and the external environment, the vapour passed through the blocks of stone material. Via periodically weighing the system, it was possible to detect the flow of water vapour that passed through the porosity of the material, determining its hygroscopic permeance. During this case study we did not want to acquire absolute measurements, but relative data, thus, to compare the difference in permeability of a porous material following a treatment with resins.

3. Results

The adhesive strength, which is considered to be the most important requirement in this case study, has been evaluated with tape test. Then, the products with a satisfying adhesive strength have been subjected to colorimetric tests, to evaluate the possible change in colour, and to permeability tests, to evaluate the variation of this parameter in the stone substrate after consolidation.

3.1. Adhesion Test

Seen in Table 2 and in Table A1 in Appendix A, with 10% and 20% Regalrez®, rabbit glue, CaLoSil®, and 5% ammonium oxalate, no adhesion was obtained, so performing the tape tests was deemed unproductive. The 3% and 10% Aquazol® 200, 5% Microacril® CV40, sturgeon glue 1:20, and 2% ammonium oxalate did not get a satisfactory adhesion between the layers. A better, but not sufficient, result was achieved with Micral-Primal® WS-24 at 33% and 50%, Acryl ME® at 25% and pure Fluoline® HY (applied twice), and with Microacril® CV40 at 10% (applied once). The 50% Acryl ME®, pure AcrilMat®, 8% and 16% Dispersion® K52, 3% Funori, 2% and 4% Tylose® MH300 showed a good adhesive strength. Nevertheless, it should be noted that the Acryl ME® and pure AcrilMat® were effective only after two applications. The first application the products likely penetrated within the porosity too in depth. Despite the effectiveness of the second application, it was decided to discard these two resins for the application on the sculpture, because their excessive penetrability makes the cohesion/adhesion operation difficult to control. The 50% Acril ME®, 5% Microacril® CV40, and 2% ammonium oxalate achieved good adhesion between the two pictorial layers, but not between these latter and the stone substrate.

Table 2. Tape test. Difference was calculated as weight after the test and before the test.

Sample Name	Number of Applications of the Consolidant	Difference of Weight (mg)	Average Weight of the Scotch Tape after Tape Test (mg) *
25% Acryl ® ME	2	243 47 57	116 ± 98
50% Acryl® ME	2	33 56 49	46 ± 11
Acrylmat®	2	0 0 0	0 ± 0
3% Aquazol® 200	2	796 - -	no adhesion
10% Aquazol® 200	2	344 552 -	no adhesion
16% Dispersion® K52	1	0 0 0	0 ± 0
8% Dispersion® K52	1	0 0 0	0 ± 0
Fluoline® HY	2	132 177 12	107 ± 82
33% Micral-Primal® WS-24	1	3 4 0	2 ± 1
50% Micral-Primal® WS-24	1	4 0 0	1 ± 1
1% Jun Funori	2	4 1 11	5 ± 5
3% Jun Funori	2	0 1 0	0 ± 0

Table 2. *Cont.*

Sample Name	Number of Applications of the Consolidant	Difference of Weight (mg)	Average Weight of the Scotch Tape after Tape Test (mg) *
10% Regalrez® 1126	1	- - -	no adhesion
20% Regalrez 1126	1	- - -	no adhesion
5% Microacril® CV40	1	762 - -	no adhesion
10% Microacril® CV40	1	0 0 337	112 ± 168
2% Tylose® MH 300p	1	1 0 0	0 ± 0
4% Tylose® MH 300p	1	0 0 0	0 ± 0
2% Ammonium Oxalate	1	0 846 -	no adhesion
5% Ammonium Oxalate	1	- - -	no adhesion
Rabbit glue Lapin	4	- - -	no adhesion
Sturgeon glue	4	748 - -	no adhesion
CaLoSil®	6	- - -	no adhesion

* The mean absolute error was calculated as semi-difference between the higher and the lower value, considering the limited number of measurements. This method allows not to underestimate the error.

The adhesives that showed satisfactory efficacy on the samples—2% Tylose® MH300p, 3% Jun Funori and 8% and 16% Dispersion® K52—therefore, were selected and subjected to the following tests. The 4% Tylose MH300p was excluded, despite its good adhesive strength, as its density makes it difficult to distribute and it causes colour saturation evident to the naked eye.

3.2. Colorimetric Test

Seen in Tables 3–6, among the tested products, 16% Dispersion® K52 caused a greater variation of the *b** coordinate: this implies a slight yellowing of the surface, although it is not perceptible to the naked eye. The ΔE_{00} of 8% Dispersion® K52 and of 3% Jun Funori slightly exceeded the value 1, so the chromatic variation was negligible.

Table 3. Colorimetric test: Average ΔE_{00}.

Resin	Average ΔE_{00}
16% Dispersion® K52	0.99 ± 0.32
8% Dispersion® K52	1.90 ± 0.42
3% Jun Funori	1.13 ± 0.24
2% Tylose® MH300	0.86 ± 0.67

Table 4. Colorimetric test: average ΔL^*(D65).

Resin	Average ΔL^*(D65)
16% Dispersion® K52	0.45 ± 0.45
8% Dispersion® K52	0.34 ± 0.55
3% Jun Funori	0.36 ± 0.20
2% Tylose® MH300	0.84 ± 0.75

Table 5. Colorimetric test: average Δa^*(D65).

Resin	Average Δa^*(D65)
16% Dispersion® K52	0.45 ± 0.38
8% Dispersion® K52	0.01 ± 0.20
3% Jun Funori	0.18 ± 0.26
2% Tylose® MH300	0.57 ± 0.17

Table 6. Colorimetric test: average Δb^*(D65).

Resin	Average Δb^*(D65)
16% Dispersion® K52	0.62 ± 1.13
8% Dispersion® K52	0.46 ± 0.18
3% Jun Funori	0.02 ± 0.38
2% Tylose® MH300	0.18 ± 0.22

The products that caused a minor colour variation are 2% Tylose MH300p and 8% Dispersion® K52.

3.3. Permeability Test

The purpose of this test is to compare the permeability of a porous material following the treatment with an intervention product. Regarding the case of a polychrome stone sculpture, the artistic technique itself leads to a reduction in permeability, since the pictorial layers tend to be less porous than the stone substrate. It is appropriate to not worsen this condition, applying where necessary a product that does not further occlude the porosity, leaving the actual level of permeability as much unaltered as possible.

As can be seen in Table 7, even though the number of samples is limited and the standard deviation is high, the test has an indicative value. It is possible to note that there were no significant differences in behaviour of the products tested, and each of them reduced permeability by approximately 20%.

Table 7. Permeability test.

Resin	Total Weight Average of Evaporated Water Vapour (mg)
No resin	985 ± 42
16% Dispersion® K52	781 ± 63
8% Dispersion® K52	746 ± 58
3% Jun Funori	764 ± 38

4. Discussion

The ideal product must achieve the cohesion of the pictorial films and the adhesion between them and the stone substrate. It must not change the gloss nor colour of the pictorial surface, it must guarantee the durability over time of both physical features and colour, avoiding by-products that would be a direct or indirect cause of alteration in the future. It must allow the retractability of the intervention. Reversibility is not considered a priority since, in the future the possibility that it will be considered necessary to remove one or more pictorial layers is remote and this operation would be possible mechanically, as demonstrated by tests on mock-ups. Therefore, we also tested inorganic consolidants, which have excellent stability over time. The ideal product must be compatible with the chosen surface cleaning methods. During our case study, different water cleaning processes were selected, after tests were performed to remove consistent deposits from the different materials of which the sculpture is made. The consolidation study started when it was not possible to select the suitable cleaning method yet; for this reason, water-sensitive products were initially included.

The critical conservative state of the pictorial layers required us to achieve the consolidation and the adhesion of polychromy simultaneously or, in some cases, even before the surface cleaning. A pre-consolidation would have fixed the substantial coherent deposits, while a preliminary cleaning would have compromised the conservation of the pictorial films. A Long Q-Switch (LQS) laser (El.En. S.p.a., Florence, Italy) was tested on some detached fragments, as this method implies low mechanical stress, but it caused the alteration of cinnabar and white lead and the partial removal of this latter. Q-Switch (QS), Short Free Run (SFR) and Erbium-YAG lasers were not tested. Some case studies [43–45] show that the first (QS laser) causes the blackening of cinnabar and white lead. The second (SFR laser) acts mainly by spallation, leading to an increase in temperature and pressure, with the risk of causing excessive mechanical stress. The Erbium-YAG laser does not induce the alteration of the white lead and cinnabar, likely due to the presence of an organic binder, which protects the pigments [46]. However, in the present study, as the pictorial layers on the sculpture are very poor in binder, its use probably would have failed. Although the possibility of cleaning by temporarily fixing the polychrome layers with cyclododecane in ligroin [24,36,47,48] also was considered, this method was found unsuitable for achieving a satisfactory level of cleaning. After tests, to re-establish the adhesion of the ochre films, which contain clay minerals, an attempt was made through moisturising (to eliminate electrostatic forces), a slight heating and pressure exerted with a thermocautery, and interposing Melinex® [12]. This process was assumed to avoid the contraindications of a pre-consolidation and the introduction of substances which are extraneous to the artwork, but it was unsuccessful in our case study. To be shown in Section 5. Conclusion, the optimal way to clean and consolidate the pictorial films consisted of introducing the selected product, waiting for it to start to polymerise and cleaning, exploiting the "softening" action released by the water of the applied emulsion. A water cleaning gel (gellan gum [49,50]) was selected for the stone surfaces, characterised by the presence of little and scattered pictorial fragments: in this case, the punctual consolidation was performed before the surface cleaning.

To select the most suitable one, some inorganic and organic (synthetic and natural) products were selected based on their viscosity and particle size, two characteristics that allow the resin to penetrate through and among the layers. To know these data, we referred to the technical data sheets of the manufacturers which, however, are often incomplete. The products whose at least one of these two parameters is indicated in the data sheets were selected and those having a viscosity $\leq$1000 mPa·s and a particle diameter $\leq$0.1 µm were tested. Polyvinyl acetate-based polymers were not taken into account because they may hydrolyse releasing acetic acid, which is harmful to the lithotype. In pictorial films, hydrolysis of the ester is favoured by temperature and humidity and could be eventually catalysed by metal cations or oxides coming from pigments [37]. Synthetic products traditionally used on polychrome stone sculptures, such as Paraloid®, were not tested, as they do not meet the viscosity and particle size requirements. An exception was made for the rabbit skin glue and the sturgeon glue, which are natural products commonly used in restoration, particularly in the field of paintings on wood, and for Funori, which was studied and applied for the adhesion of polychromy on stone also [24,51]. These resins have the advantage of being easily removable over time without using organic solvents, and of having a low toxicity.

Following the tests, it was decided to use the acrylic microemulsion Dispersion® K52 for the consolidation of the pictorial layers that cover the stone surfaces of the Virgin and the Child, thanks to its excellent adhesive strength, the absence of significant chromatic variations and its comparability with other products in terms of permeability.

Jun Funori provided excellent results and has a better stability to UV radiation than the acrylic resins [24,25,27,42]. Nevertheless, the cleaning tests performed on the Virgin with the Child revealed the suitability of the aqueous methods, which are incompatible with Funori. Regarding the average photosensitivity of the acrylic resins [39,52], we must consider that the selected microemulsion has a good penetration capacity, thus reducing this shortcoming; also, the risk of the presence of residues on the statue surfaces was reduced by cleaning with cotton swabs during the application phase. We finally must consider that the sculpture is conserved in a museum environment. It, therefore, is possible and necessary to monitor not only the thermohygrometric parameters, but also the exposure to light, avoiding irradiation with UV rays. These conditions also are essential to prevent the alteration of some constituent materials of the work of art itself, such as cinnabar, which are sensitive to light.

It seems clear that the adhesion of pictorial layers on a stone substrate causes a reduction in permeability. The water can leave a deposit of salts under the treated surface, which can rehydrate and recrystallize at any thermo-hygrometric variation. These phenomena lead to mechanical stresses within the porosity, causing breakages at the interfaces and the decohesion of materials [53]. The moisture that accumulates below the impermeable surface also can react with the constituent materials of the polychrome sculpture, such as the silver foil and the lithotype, thus participating in the formation of carboxylates [12]. Over the centuries, in addition to the siccative oil and the probable lean tempera, silver and golden foils were applied to decorate the work of art. Consequently, it is certainly necessary to deepen this research, to formulate more suitable products. Future research must focus not only on the compatibility, stability over time, retractability, good adhesive strength, and absence of chromatic alteration, but also on the permeability variation, caused by the introduction of an adhesive/consolidating agent in a complex and heterogeneous system.

5. Conclusions

The application of Dispersion® K52 on the pictorial films of the sculpture confirmed the good results that emerged from the tests. The resin was applied by syringe at 8 and 16% in demineralised water over the pictorial layers which were in a state of decohesion and loss of adhesion, after the application of water and ethanol at 50%. This allowed us to lower the surface tension and to partially wash away the deposits which were accumulated under the pictorial layers. Regarding more localised applications, the same product was used at 10% in isopropyl alcohol [35], avoiding the use of water and ethanol at 50% and the consequent dispersion. The introduction of the microemulsion hydrated the coherent deposits, allowing us to easily remove them with swabs or scalpels, reaching a satisfying cleaning level, without affecting the polychromy, thanks to the initial crosslinking of the resin. The microemulsion also softened the pictorial layers, allowing us to lay down the pictorial scales on the stone substrate, exerting a slight and gradual pressure with a spatula and swabs, and interposing Melinex®. After that, the pictorial layers were more legible (Figure 4).

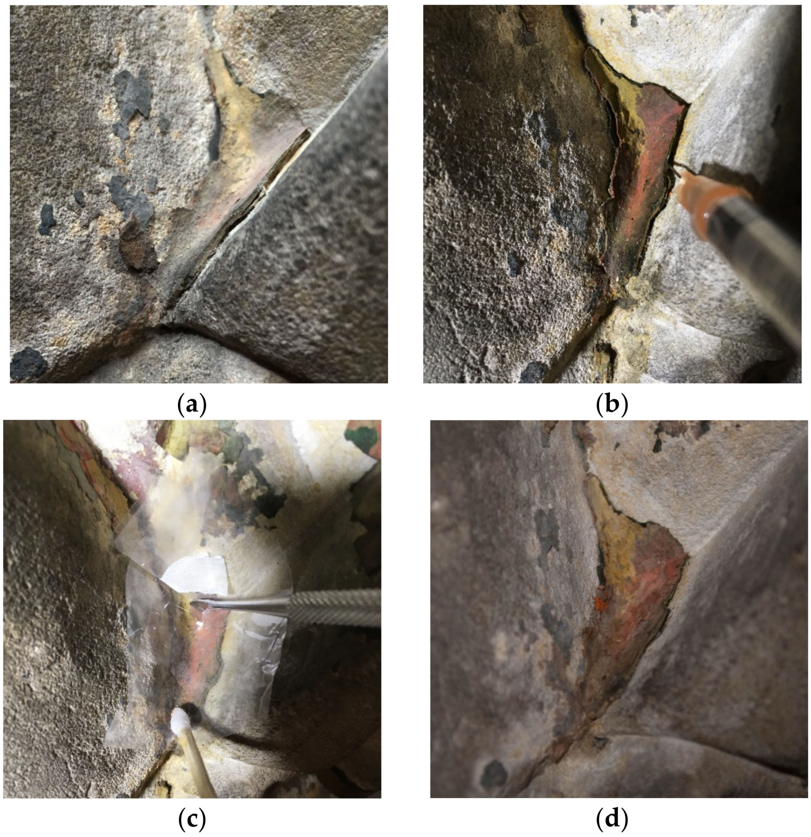


Figure 4. (**a**) The pictorial layers before the consolidation by syringe (**b**), cleaning with buffers and exerting a gradual pressure to adhere the films to the substrate (**c**). (**d**) After the consolidation.

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Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Table A1. The specimens subjected to tape test.

Before Tape Test	**After Tape Test**
	
25% and 50% Acril® ME	25% and 50% Acril® ME
	
AcrilMat®	AcrilMat®
	
3% and 10% Aquazol® 200	3% and 10% Aquazol® 200

Table A1. *Cont.*

Before Tape Test	After Tape Test
	
16% Dispersion® K52	16% Dispersion® K52
	
8% Dispersion® K52	8% Dispersion® K52
	
Fluoline® HY	Fluoline® HY

Table A1. *Cont.*

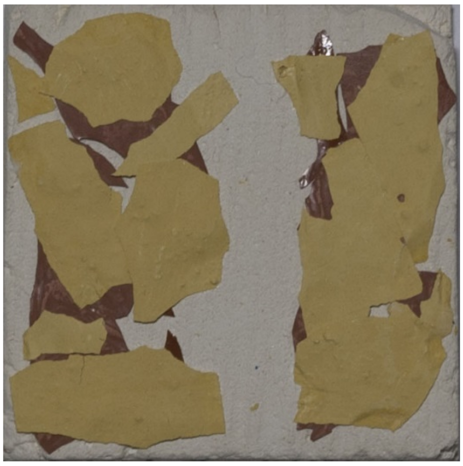
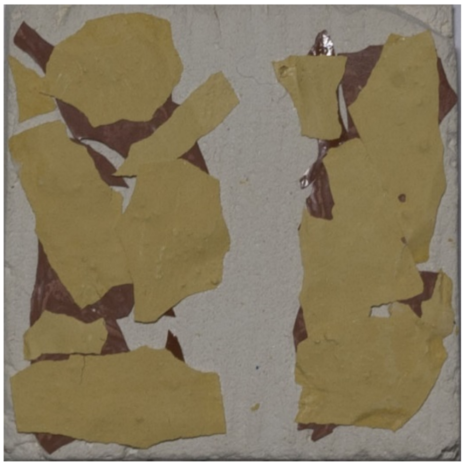
Before Tape Test	After Tape Test
	
33% and 50% Micral-Primal® WS-24	33% and 50% Micral-Primal® WS-24
	
1% and 3% Jun Funori	1% and 3% Jun Funori
	
10% and 20% Regalrez® 1126	10% and 20% Regalrez® 1126

Table A1. *Cont.*

Before Tape Test	After Tape Test
 5% and 10% Microacril® CV40	 5% and 10% Microacril® CV40
 2% and 4% Tylose® MH 300p	 2% and 4% Tylose® MH 300p
 2% and 5% ammonium oxalate	 2% and 5% ammonium oxalate

Table A1. *Cont.*

Before Tape Test	After Tape Test
 CaLoSil®	 CaLoSil®
 Rabbit glue Lapin and sturgeon glue	 Rabbit glue Lapin and sturgeon glue

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