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MOISTURE SENSITIVE EASEL PAINTINGS: A PRACTICAL APPLICATION OF FILLING AND TEXTURING OF LOSSES WITH AQUAZOL® BASED FILLER

Daniel Morales-Martín (1)
Antonella della Festa (1)
Alicia Sánchez Ortiz (1)

(1) College of Fine Arts, Complutense University of Madrid; 2 Pintor el Greco, Madrid, 28040, Spain. damora03@ucm.es

ABSTRACT

The filling of losses in easel paintings must provide the level and texture of the original pictorial layers. Synthetic poly-2-ethyl-2-oxazoline based stucco (Aquazol®) has been one of the latest additions with good results in the filling of paintings on canvas. The main objective of this research is to determine the properties of Aquazol® 200 based filler as a texturing filling with respect to its workability and its mechanical behaviour in relation to the structural stability of different textile substrates. To this end, two case studies have been used as a starting point, both of which share the need to find a stucco that does not add moisture to the canvas and that can reproduce the texture of the painting layer. In the experimental part, 18 mock-ups were made reproducing the pictorial surface of each work, as well as the restoration treatments of their supports. These were subjected to accelerated ageing to qualitatively analyse the stability of the filling before and after. After testing, it was found that Aquazol® 200 has excellent qualities for levelling and texturing gaps on moisture-sensitive substrates. The good ability to reproduce brush grooves, small impasti and smooth surfaces is noteworthy. On the other hand, a satisfactory result was not achieved on very pronounced impasto, requiring further study.

Keywords
Aquazol ®; Canvas; Filler; Impasto; Texture.

1. INTRODUCTION

A conservation-restoration intervention, according to the current criteria and methodologies, does not have a standardized and generalizing character. This requires the specific adaptation of each treatment and its materials according to the needs of each particular work of art. Thereby, the conservator approaches each intervention as a unique and singular case of study. Thus, a methodical approach is developed, consisting of studies and experimental tests whose possible application to the painting in question is made after interpretation of the results [1].

It is along this lines that the present investigation was conceived, which arose from the need to tackle the process of filling the losses in the pictorial surfaces of two easel paintings that share a common problem: high sensitivity to humidity. In addition, the topographical characteristics of the paintings must be reproduced at this stage. One of the paintings shows a surface marked by the furrow of the bristles of the brush, while the second combines a smooth finish with fine brushstrokes and different impasti applied with a palette knife.

Over the years, different fillers of natural and synthetic origin have been studied, both self-made and commercially available, with the aim of minimising or supressing the contribution of moisturising during the filling process. However, all of them have a series of advantages and disadvantages according to the particularities of each case of study, such as the number, size and morphology of the losses, or the type of texture of the surface to be levelled, among others [2].

1.1 Filling texturization

From the beginning of the restoration discipline itself, and according to the treatises of the time, the texturing of the filling material was carried out to improve the integration with the pictorial fabric during the retouching phase. Vincente Poleró describes how to reproduce the weft of the support by means of an incision system [3]. However, the imprint of the weft is not the only aspect to be reproduced, but many others specific to the artist´s pictorial technique. In addition to the effects of the degradation of the work, such as cracking due to age or premature cracking.

For the texturing of the filler, the type of surface to be reproduced, the constituent materials and their compatibility with the different filling options, the subsequent retouching, the finish varnish, and the environmental conditions in which the piece is to be exhibited, must be considered.

Generally, without having to resort to flexible moulds, making different fillings involves working with soft or biting fillers. Within this category, and among the binders that do not provide excess moisture to the painting during their application, are acrylic based fillings, polyvinyl acetate based fillings, polyvinyl alcohol based fillings and polyethylene glycols. However, according to the studies carried out, the first three become irreversible over time, while the latter present a certain incompatibility with the constituent materials of traditional paintings. The thermoplastic fillers are another alternative but are difficult to work with when it comes to imitating textures such as brush strokes [2] [4]. On the other hand, commercial fillers have optimal properties for texturing, but in most cases part of their chemical composition is unknown [5].

1.2 Aquazol® based filling

One of the latest additions has been a synthetic filling made from a thermoplastic polymer of poly-2ethylene-2oxazolin (trade name Aquazol®). This material has a solid application in the field of conservation-restoration, especially as a consolidant of matte surfaces and, recently, as a pigment binder for pictorial retouching [6] [7]. Within this last application, it has also been tested in the preparation of painting pastes in order to carry out the illusionist chromatic reintegration in a single step, eliminating the filling phase. However, the results obtained with fillers bound with Aquazol® 200 20% in water, Aquazol® 500 20% in water and Aquazol® 500 20% in water emulsified with 50% egg yolk were not satisfactory. These pastes, prepared in a 1:1 binder/pigment ratio, crack after drying [8].

There are different types of Aquazol® in the market depending on their molecular weight, from 5,000 a.m.u. to 500,000 a.m.u.. In the restoration field, the most commonly used are 50, 200 and 500, especially the last two. The main difference between the two lies in their adhesive power, which is closely and proportionally related to their molecular weight. Thus, Aquazol® 500 is more adhesive than Aquazol® 200, although both products are weak adhesives [9]. This aspect also influences the purpose of their use, as they are ideal materials for the adhesion and consolidation of coloured layers with a high elongation capacity. The use of one or the other will depend on the morphology and pore size of the surface to be treated, as well as the degree of penetration required [10].

Thanks to previous studies, the stability of the filling based on Aquazol® 500 and Aquazol® 200 against different degradation agents is known, obtaining as conclusions their optimal physico-chemical and mechanical behaviour. In addition, they are inert to biological attack. One of the most relevant aspects of these analyses was the great similarity between the filling studied and the animal glue filling, known as traditional [11] [12].

This poly-2ethylene-2oxazoline based filler is unstable against ultraviolet radiation. Under this degradation factor the binder gives rise to the formation of amides due to the breakage of its main chain [5]. Therefore, the filling must be protected by an insulating layer, either an intermediate retouching varnish or a final varnish [12].

Given the qualities of this binder the coating process is safer, as there is no contraction phenomenon during drying [11]. It can also, among other things, reduce or eliminate the contribution of humidity to the item as it is soluble in polar solvents.

Another of the alleged qualities of Aquazol® based fillers is that they allow coloring to facilitate the subsequent retouching process. This aspect has been analyzed in fillers prepared with Aquazol® 500 at 10% in ethanol plus one part of calcium carbonate and one part of pigment. The conclusions drawn in the study consider this product to be a poor binder due to its high viscosity and difficult workability [13].

The objectives of the following research are to determine the proprieties of Aquazol® 200 based filling as a texturing filler and to determine its behaviour in relation to the mechanical stability on textile substrates that are sensitive to humidity.

2. MATERIALS AND METHODS

2.1 Painting under study

Case 1: Anonymous (XVII century). *Petronia Vitelli Uxor*. [oil on canvas]. Madrid: Private collection. (Figure 1). This painting has the following stratigraphic structure: linen canvas (support), animal glue (insulation layer), earth colour oil (primer), oil size (paint) and natural resin varnish (protection layer). The sensitivity to moisture of this painting is caused by the remaning animal glue of an old flour paste canvas lining. Following the methodology proposed by Enrica Boschetti, the adhesive was removed leaving a small amount to consolidate the fibres of the original fabric [14]. After this process, tension bands with a polyester fabric (Trevira Ispra®) were applied and textile intarsia was made with the same synthetic fabric, with a silk crepeline reinforcement and thread bridges, all bonded with Beva 371®. After cleaning the pictorial surface and filling, which will have to reproduce the grooves of the brush bristles, a retouching varnish (Regal retouching varnish®) will be applied, and the retouching will be carried out according to the criteria of the *selezione cromatica,* using QoR® watercolours. Finally, a layer of varnish (Regal varnish gloss®) will be applied.

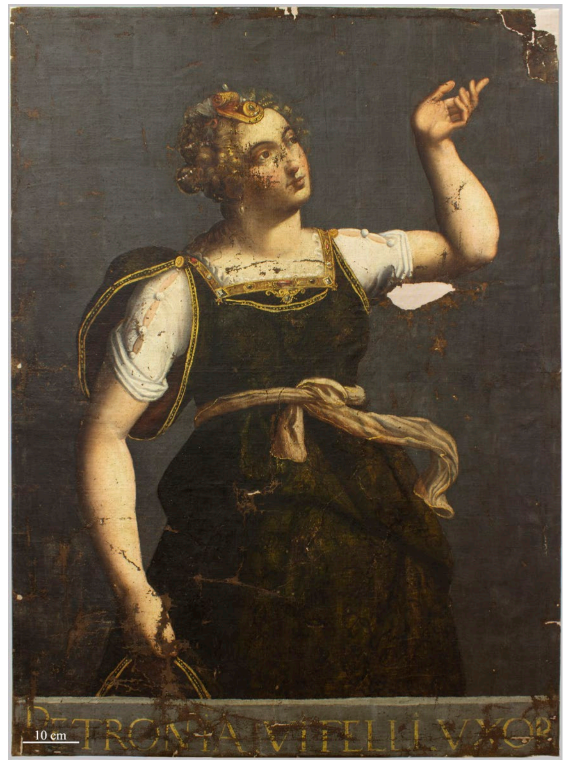


Figure 1 – Front of the painting *Petronia Vitelli Uxor* before filling.

Case 2: Anonymous. (XX century). *Landscape* [Oil on cotton]. Granada: Private collection. (Figure 2). This painting has the following stratigraphic structure: cotton canvas (support), synthetic ground (ground) and oil size (paint). In this case the sensitivity to humidity is caused by the nature of the pictorial support itself. The treatment of this item consisted of textile intarsia with polyester fabric (Trevira Ispra®) and a reinforcement of silk crepeline and thread bridges adhered with Beva 371®. After surface cleaning, the losses will be filled. Their surface texture, which has brush grooves, touches and spatula impasto, should be reproduced. Afterwards, an insulating layer of 5% Paraloid B72® in Dowanol™ PM spray will be applied over the fillings. The retouching will be carried out according to the mimetic retouching method, with QoR® watercolours. To conclude, a final protective layer of 10% Paraloid B72® in Dowanol™ PM spray will be applied.

Figure 2 – Front of the painting *Landscape* before filling.

2.2 Making of the mocks-ups

The creation of the models was subjected to four main criteria: 1) the type of impasto to imitate, 2) the type of loss, 3) the treatments already carried out on the works and 4) the future treatments that will be carried out on the works once this study has been completed. A total of 16 20x18 cm mock-ups were made, the properties of which are shown in table 1.

Mocks-ups case 1:
Reproducing the characteristics and treatments of the support involved carrying out the following sequence: lining (using 'gacha', traditional flour and animal paste), removing the lining, removing the adhesive, and applying tension bands. In the models where the lack of the original fabric was simulated, reinforced textile intarsia was made. In the intervention phases, the steps and materials used on the real paintings were followed. A 100% natural fatigued linen was used as original canvas. In accordance with the stratigraphic study, a layer of animal glue, a layer of an earth colour primer and a layer of hand-prepared black oil paint (carbon black pigment bound with linseed oil) were applied to the canvas.

The losses filling was done using a 10% Aquazol® 200 based filler in a hydroalcoholic solution (25% water/ 75% ethanol) and calcium sulphate until saturation. This preparation process is the same as for the traditional stucco. However, given the viscosity of the binder concentration, the settling time of the solid material is much longer. In this way, the preparation of the filler is slower, since the calcium carbonate is added, the glass bottle is covered to prevent the evaporation of the solvents and it is left to decant. This process is repeated until the liquid is saturated. In both types of losses, the filling was applied by drip and then levelled with a spatula. The surface was textured with a stiff-bristled brush following the directions of the brushstroke. At some points, to reinforce the texture or correct imperfections, the filling binder was activated with an aqueous solution and textured again.

Mocks-ups case 2:
An industrially prepared (synthetic ground) open weave cotton canvas (Phoenix®) was used as original support. For the pictorial layer, an industrially produced green oil paint (Titan® 65) was selected. It was applied with a palette knife to generate more pronounced impasto and with a brush for the touches and the smooth surface areas. The intervention on the mocks-ups where the loss of the pictorial support was simulated was carried out according to the methodology and materials used in the real painting.

The losses filling was done using a 10% Aquazol® 200 based filler in a hydroalcoholic solution (25% water/ 75% ethanol) and calcium sulphate until saturation. In the losses where to imitate the brush groove, the same procedure was followed as in the mocks-ups of the case 1. In the samples with impasto, the losses were first filled and then levelled. Once dry, more filling was applied with a spatula according to the topography surrounding the missing surface. For the mocks-ups where the pictorial surface is composed of touches, the same procedure was followed. At some points, to reinforce the texture or correct imperfections, the filler binder was reactivated with an aqueous solution and textured again.

Table 1 – List of models made for the experimental study

Mock-up	Real case	Type of loss	Type of impasto	Varnish
1	Case 1	Pictorial layer	Brush groove	Yes
2	Case 1	Pictorial layer	Brush groove	No
3	Case 1	Textile	Brush groove	Yes
4	Case 1	Textile	Brush groove	No
5	Case 2	Pictorial layer	Brush groove	Yes
6	Case 2	Pictorial layer	Brush groove	No
7	Case 2	Textile	Brush groove	Yes
8	Case 2	Textile	Brush groove	No
9	Case 2	Pictorial layer	Knife palette	Yes
10	Case 2	Pictorial layer	Knife palette	No
11	Case 2	Textile	Knife palette	Yes
12	Case 2	Textile	Knife palette	No
13	Case 2	Pictorial layer	Touch	Yes
14	Case 2	Pictorial layer	Touch	No
15	Case 2	Textile	Touch	Yes
16	Case 2	Textile	Touch	No

2.3 Experimental trial

The models were subjected to accelerated ageing in a climatic chamber where they were exposed to variations in relative humidity (cycles of 30% and 90% RH) for 168 hours. The parameters have been selected according to De Luca, Borgioli, Orsini, and Buratt´s study, but the minimum value of relative humidity was adapted to the climate of Madrid (exhibition place) [12]. Before and after this treatment, the stability of the filling in relation to the mechanical behaviour of the pictorial ensemble was qualitatively studied with grazing light and on a macro and microscopic scale (Dino-lite® AD4113T-I2V).

3. RESULTS AND DISCUSSION

3.1 Application properties

The elaborated filling has plastic properties very similar to those of a traditional stucco, which allows for drip filling. In terms of its texturization, it allows its surface to be modelled both when fresh and when dry and can be easily reactivated with an aqueous or alcoholic solution.

During the drying of the filler, no shrinkage of the material was detected. At 50x magnification, no fissures or cracking were observed at the contact edge between the filling and the paint. Likewise, the fillings were not altered and/or modified after solidification.

As far as the reproduction of the textures is concerned, the best result was obtained in the models where the aim was to imitate the grooves of the brush. However, the filling of the impasto with a palette knife was not completely satisfactory, as they were not faithful to the original surface, producing an impasto with sightly soft edges. Despite this difference, the loss integrates with the original topography, closing the figurative fabric of the painting. In the reproduction of the impasto by touches, the result obtained was the same as in the previous case.

3.2 Mechanical behaviour of the filling after accelerated ageing

Paintings that have been lined with flour paste undergo a change in their biaxial mechanical behaviour after the lining is removed. According to studies carried out by Alain Roche, in the case of relative humidity fluctuations, the stresses in a painting whose lining has been removed (unlined) are different to those of the painting before being lined. However, the behaviour curves of the painting in both situations are similar, unlike the curve for the lined painting which is more fluctuating. The tension values of the unlined painting are higher than those of the original painting, but lower than in the lined painting.

The tension of both the original and the unlined painting remains constant up to 30% RH. From this point on, it starts to decrease slightly up to 70% RH, where the tension quickly reaches its minimum value. This remains stable up to 95% RH. Therefore, the lining removal process involves a change in the mechanical stability of the work, which results in higher tension values [15].

As for cotton supports, and in relation to a contemporary pictorial structure, they show the following behaviour in relation to variations in RH: the initial tension of the work nailed to a stretcher frame begins to decline slightly from 30% RH until it gradually reaches a lower tension at 95% RH [16].

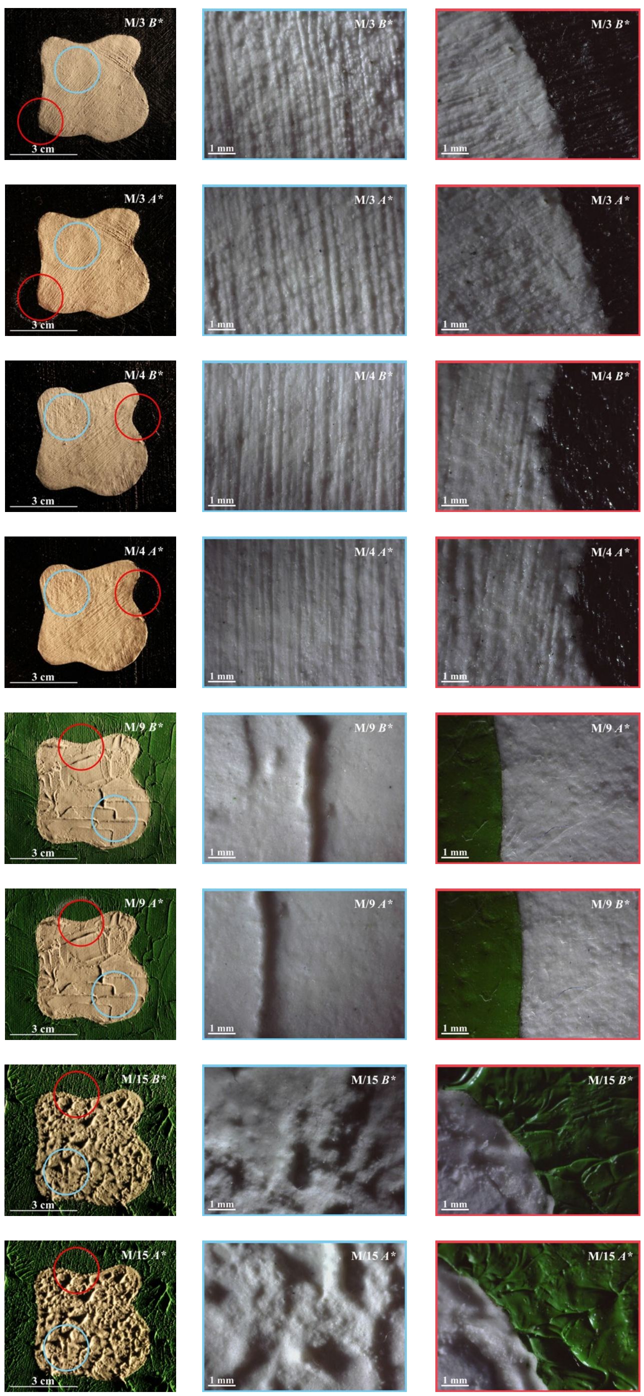
According to the observations made during the course of the experimental test in the climatic chamber, the textile intarsia treatment and its reinforcement did not intervene in the movement of the support for the following reasons: the polyester fabric used for the reintegration of the missing support is inert to changes in humidity [17]; the reinforcement system used does not significantly interfere with the tension/relaxation movements of the canvases as it is a point method adhered with a flexible adhesive [18].

After exposure to relative humidity cycles, it was possible to see how the 10% Aquazol® 200 based filler adapted to the different movements of the textile supports in both cases. There are no differences between the models where textile intarsia has been applied and those where it has not. At 50x magnification, no separation, cracking or craquelure can be detected in the filled loss or around the contact edge with the original paint (table 2). Likewise, no stresses have been produced to the support that could lead to distortions.

The good mechanical stability of the stucco is due to the physical properties of poly-2-ethyl-2oxazoline.

Table 2 – Results of filling and texturization of losses in the mocks-ups 3, 4, 9 and 15 before and after accelerated aging in climatic chamber.

Raking light photography	50X micrography with grazing light of the texture	50X micrography with grazing light to the edge of loss



B: Before accelerated aging
A: After accelerated aging

This morbid material has a Tg 69°C which makes it behave like a plasticising substance. Furthermore, this amorphous polymer with a modulus of elasticity equal to 104.2 MPa is considered a flexible substance as this parameter is lower than 400 MPa. After thermohygrometric ageing, it remains flexible and loses stiffness during ageing due to a process of polymerisation rather than cross-linking [10].

3.3 Application to real cases

The application of the results obtained in the experimental part to the corresponding case studies has made it possible to bring said results closer to reality. In this last research process, the same materials and methods tested on the models have been used.

In the first case study, it was possible to reproduce the texture of the original surface without difficulty. No movement of the textile support was observed during the stuccoing of the large losses. After intermediate varnishing and retouching with QoR® watercolors, a phenomenon known as the *lotus effect* occurred occasionally in the losses where the brushstroke texture was most intertwined. This is caused by the hydrophobicity of a surface due to a two-level microstructure. When liquids with a high surface tension are deposited on it, drops can form with a contact angle of more than 90º [19]. The effect manifested visually as a division of the strokes into small drops of color. The medium used to dilute the watercolors was water (surface tension 72.8 dynes/cm). After this, water was replaced by 2-propanol (21.7 dynes/cm) to reduce the surface tension. With this solvent, the retouching lines could be drawn correctly.

In the experimental part of the second case study, the results were not fully satisfactory in the reproduction of spatula impasto. However, this type of relief was only to be achieved in small areas and, therefore, it was finally decided to use the same materials and methods used in the tests for the filling of the painting *Landscape*. After this phase, where it was mainly necessary to reproduce a smooth surface combined with small impasto touches, a fully satisfactory finish was obtained. Given the experience in color reintegration in case 1, in this second phase, 2-propanol was used directly to dilute the QoR® watercolors.

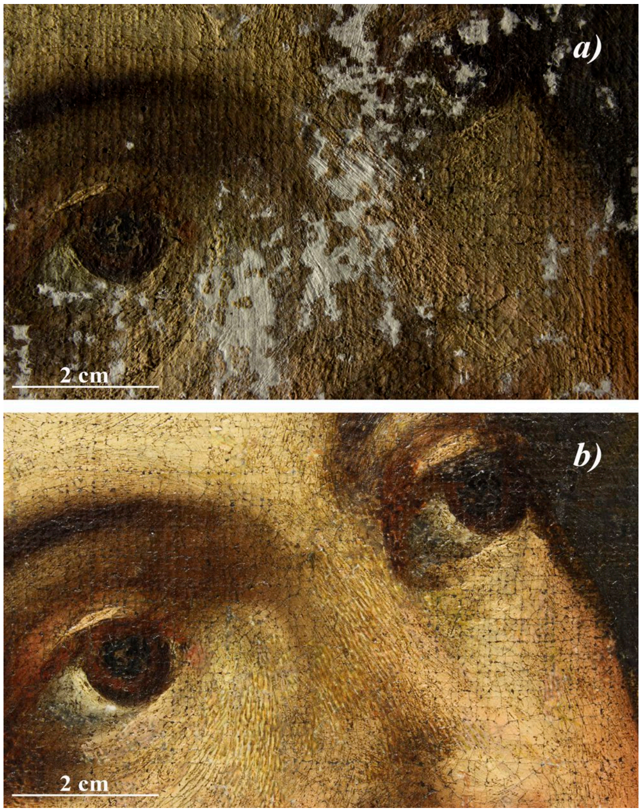


Figure 3 – a) Detail of the filling in case 1 with raking light b) Detail of the retouching of the case 1 with visible light.

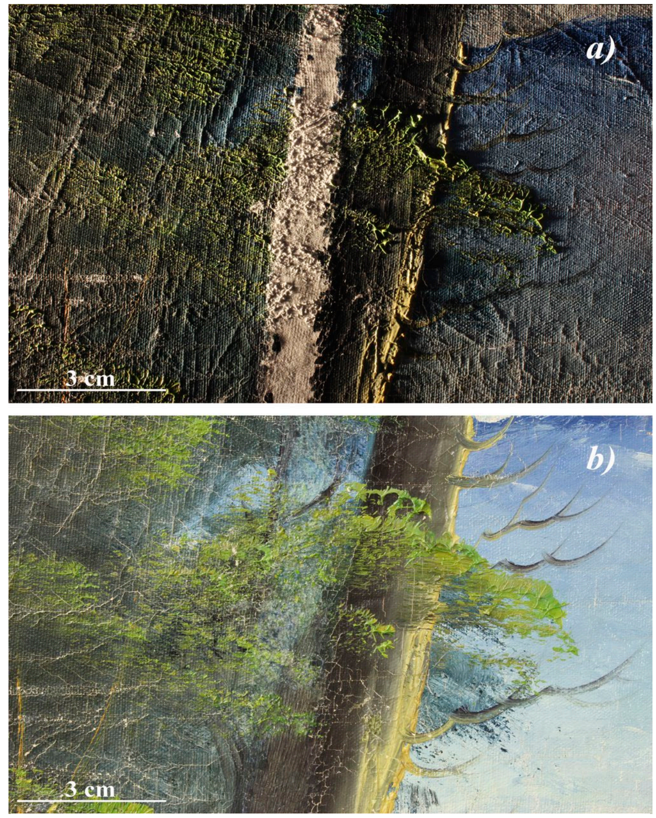


Figure 4 – a) Detail of the filling in case 2 with raking light 2. b) Detail of the retouching of the case 2 with visible light.

4. CONCLUSIONS

Tests have determined the optimum qualities of this filler for levelling gaps in substrates sensitive to humidity. In terms of its texturing properties, the ability to reproduce brush grooves, small impasti and smooth surfaces is noteworthy. On the other hand, a fully satisfactory result has not been achieved on samples of very pronounced impasto, requiring further study.

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