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THE INFLUENCE OF FILLERS ON THE CHROMATIC REINTEGRATION PROCESS ON EASEL PAINTINGS: ANALYTICAL STUDY FOR SKIN COLOR

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ABSTRACT

Mimetic chromatic reintegration in easel paintings is usually achieved by levelling the surface of losses (lacunae) with a white filler, followed by its retouching with an appropriate paint.
This investigation aimed to understand how different formulations of fillers (colored fillers and white fillers covered with three kinds of paints: watercolor, gouache, and mastic resin) influence mimetic reintegration. Colorimetry, using a smartphone with a color measurement application, and Fiber Optics Reflectance Spectroscopy (FORS) measurements were made on 29 samples of fillers and on the surface of the pictorial layer of our case study - a painting by Veloso Salgado.
The combined use of these techniques allowed us to choose the most similar material filler system. The pigmented fillers gave us the best results to perform a safer and faster chromatic reintegration procedure. This procedure appears to be suitable for contemporary art as which usually do not present a protective layer. Also, the use of pigmented fillers simplifies the color achievement.

Keywords
Easel Paintings; Fillers; Chromatic reintegration; FORS; Colorimetry.

1. INTRODUCTION

The use of white fillers, followed by an appropriate surface toning, is a standard restoration intervention for losses, whether on flesh tones or other painted elements on a canvas [1].

Chromatic reintegration is usually the final step in a conservation and restoration intervention and can cause a visual impact on the overall aesthetics of a painting. The main goal is to reintegrate the losses allowing the viewer to appreciate the artworks without the interference of the loss or the chromatic reintegration itself [2].

When considering the materials for filling losses in easel paintings, scant attention is paid to the broad offer of brands and formulations. Consequently, the matching color becomes more complex and time-consuming due to some problems of texture, levelling, absorbency, among others. So, the success of chromatic reintegration starts with the appropriate selection of the filling material [3], to reduce these inconvenient consequences.

Recognition of the influence of filling materials is so far done empirically. Initiatives on this subject are not so

numerous, as well as the studies that combines both techniques of color measurements focused on flesh skin tone. In addition, reflectance spectroscopy is a technique mostly used for pigment identification and in this case, the data comparison between samples is also a new field of investigation.

As the name implies, the objective of the mimetic method of reintegration is to achieve the color as much similar as the original on the painting [4]. The correct choice of the filling material can simplify this process.

The main goal of this investigation was to propose a methodology to support the choice of an appropriate filler formulation using colorimetry and reflectance spectroscopy, specifically on the flesh (skin) zones. To accomplish this the following objectives were specified:

• Identify the constituent materials of the painting under study, reviewing the scientific publications about the painter, Veloso Salgado, on his paintwork [5] [6] [7]. Also, to review the state of the art concerning analytical equipment over color and pigments identification, focusing on colorimetry based on applications for smartphones and, on FORS [8] [9].

• Select the filling materials and the pigments to formulate the colored or pigmented fillers. For comparative purposes, traditional fillers (made of skin glues), synthetic formulations and fillers manufactured commercially, were tested.

• Preparation of a mockup with 29 samples for analysis:
- 21 non-pigmented formulations
- 8 pigmented formulations

Over these 21 non-pigmented formulations three paints were used: 7 samples were painted with Winsor & Newton® watercolour, 7 samples with Royal Talens® gouache, and 7 with samples with mastic resin from Maimeri®. Samples were dried for one month after mockups conclusion.

The 8 pigmented formulations were prepared with a mixture of pigments according to the output of FORS database, that indicated the most similar pigments to the ones measured on the surface of the pictorial layer from the painting.

• Make use of portable and low-cost equipment, supported by previous studies with the same kind of devices, aiming to measure the samples and the painting.

• Validation of the methodology on a painting. The chosen painting, conceived by José Maria Veloso Salgado (2 April 1864 – 22 July 1945), is from the Faculty of Fine Arts, University of Lisbon. Veloso Salgado is a Portuguese artist regarded as one of the country's foremost masters of Naturalism with many works on historical painting, landscapes, and portraits. The chosen painting, made around 1889, represents a male nude. The relevant presence of chromatic layer losses on the flesh was the criteria for selection (Figure 1).

Figure 1 – Oil painting by Veloso Salgado, analyzed during this study.

2. MATERIALS AND METHODS

Below we present the methodology used, which allowed us to prepare and select the most appropriate materials for filling losses in the easel painting selected as a case study.

2.1 Measurement of color and visible light reflectance parameters at the painting

Colorimetry and reflectance spectroscopy measurements were made at intact flesh tone areas from the painting surface, adjacent to paint losses.

Colorimetry was made under a smartphone application (Color Picker®) with an Android 9.0 operational system. The visible reflectance data was achieved with a FORS device (Figure 2), model Gorgias® manufactured by CHS Opensource, operating with a halogen tungsten lamp, color temperature of 3.000 K, a detector CCD Toshiba TCD1304DG with 3648 pixels, and fiber optics cable with seven channels of 600 micron wide each.

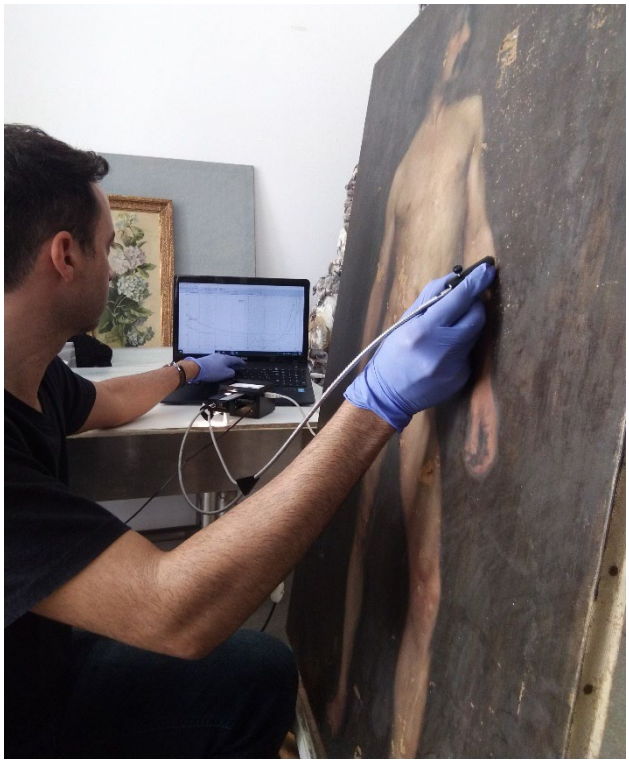

Figure 2 – Measurement of light reflectance by FORS.

2.2 Bibliography survey of the chromatic layer constitution

Literature was collected [5] [6] [7], focused on previous studies about the stratigraphy and the identification of pigments used at this painting and other paintings from the artist.

During a previous study [5], a micro-sample on the border of a loss was removed to observe the chromatic layer structure. This result was used to comprehend the painting technique used by the artist.
X-ray fluorescence and Raman spectroscopies were applied on the same sample to identify the pigments used by Veloso Salgado on the flesh zone.

The literature also showed the methodologies from other artists at the same time and academic references (Portugal and France academies by the end of 19th century).

2.3 Mock-up creation

A mockup of 29 samples was created according to the proposed formulations (Figure 3). The first 21 filling materials were prepared with calcium carbonate and gypsum, combined with three different binders: a traditional one - rabbit skin glue, and two synthetic – the vinylic Mowilith DS 5/2® and the acrylic Plextol B500®. A ready-made putty was also used, Modostuc Bianco®, on samples 19, 20 and 21 (as seen on Figure 3).

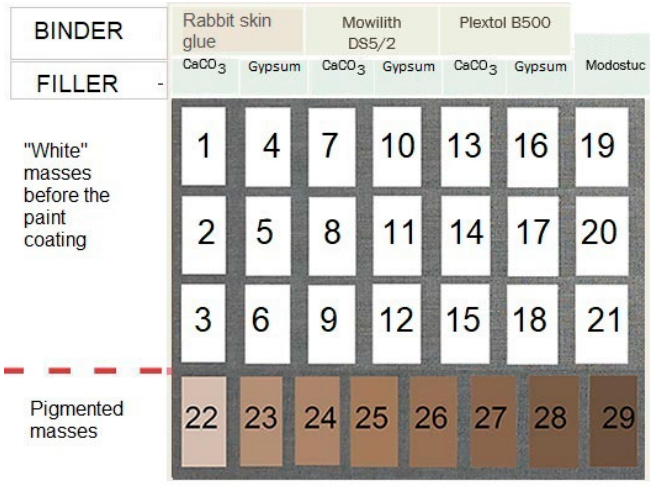

Figure 3 – Mockup scheme before the application of the paint coating to samples 1 to 21.

2.4 Painting's application over samples 1 to 21

Samples 1 to 21 were coated with paints typically used for conservation [10], such as watercolor from Winsor&Newton®, gouache from Talens®, and mastic resin from Maimeri®. We aimed to paint the samples

with pigments similar to the ones used at Veloso Salgado's painting. The inputs from literature on scientific studies [5] [6] [7] [11] considering the flesh area composition were essential to the decision-making process (Figure 4).

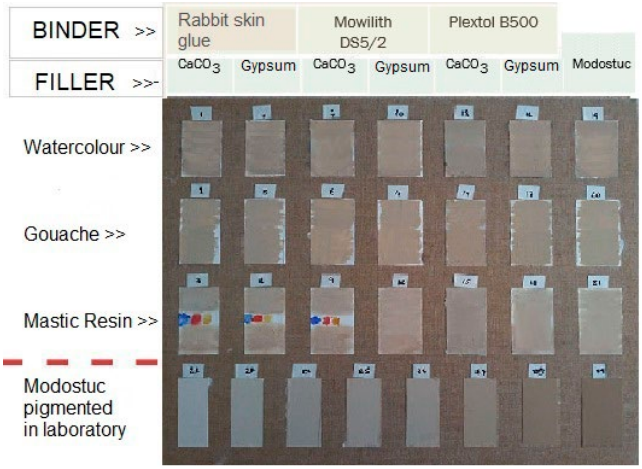

Figure 4 – Mockup ready for the measurements.

2.5 Painting's application over samples 22 to 29

The last eight samples from the mockup were prepared with an industrial putty (Modostuc Bianco) with the gradual addition of pigments accomplishing a lightness scale. Samples were painted with a mixture between Burnt Umber (PBr7) and Raw Siena (PY43). These two pigments were identified by a FORS measurement at the area representing the flesh (skin) from the painting.

2.6 FORS and colorimetry measurements on the 29 samples from the mockup

FORS and colorimetry measurements from the 29 samples were made. We aimed to compare the results of the mockup samples with the "original" flesh color from the painting and choose the two most similar samples. So, two samples were chosen:
- a sample from the "filler + paint" system (between samples 1 to 21)
- a sample from the "pigmented filler" system (between samples 22 to 29).

2.7 Execution of chromatic reintegration at the painting with the chosen samples

An exercise of chromatic reintegration was made at some paint losses from the painting, with the two selected samples, according to the methodology. Both chromatic reintegration areas were analyzed by FORS and compared with the original area enabling the validation of the methodology.

3. RESULTS AND DISCUSSION

3.1 Selection from the "filler + paint" group of samples

Below we present (Figures 5, 6 and 7) the first group of results. These show the comparison between measurements from the first 21 samples on the mockup separated by the type of paint for better visualization and, the one obtained at the painting:

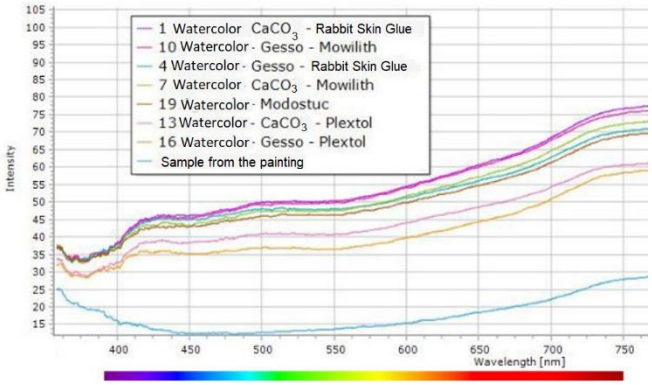

Figure 5 – FORS results obtained for watercolor samples and flesh color from the painting (sample).

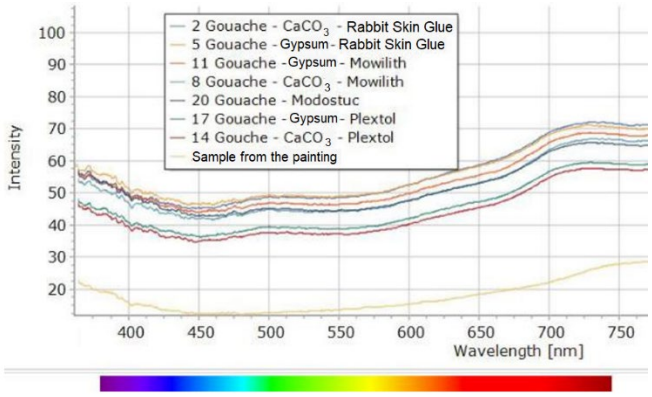

Figure 6 – FORS results obtained at gouache samples and flesh color from the painting (sample).

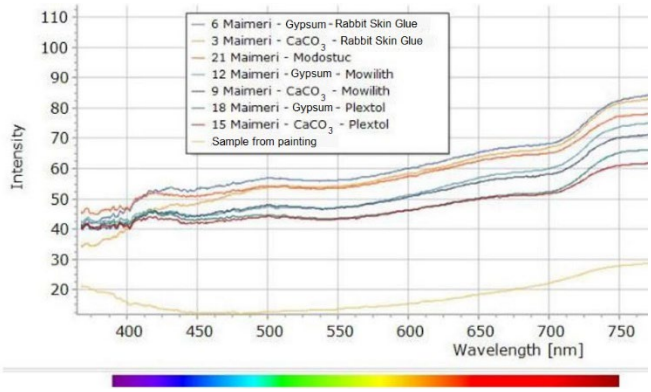

Figure 7 – FORS results obtained for mastic resin samples and flesh color from the painting (sample).

As we can see above on the visible spectrum frequency (mainly above 450-750 nm), the curves present similar shapes between themselves and the Veloso Salgado painting. We consider that without support from colorimetry, the FORS outputs are not conclusive enough because the similarity of the obtained spectra.

Below, we present the ΔE results from CIE Lab color space when compared with the measurement at the painting:

Table 1 – ΔE results from samples 1 to 21, compared to flesh tone at the painting.

CIE Lab color measurements					
Sample	Paint	Lightness	- a +	- b +	ΔE
21 Modostuc	Mastic resin	61	2	6	9,9
7 CACO3 + Mowilith	Watercolor	61	0	4	11,8
8 CaCO3 + Mowilith	Gouache	61	-1	4	12,1
17 Gesso + Plextol	Gouache	58	-2	4	11,0
3 CaCO3 + Rabbit S. Glue	Mastic resin	62	1	4	12,2
4 Gesso + Rabbit S. Glue	Watercolor	58	1	3	11,0
1 CaCO3 + Rabbit S. Glue	Watercolor	63	1	4	12,9
12 Gesso + Mowilith	Mastic resin	63	1	4	12,9
14 CaCO3 + Plextol	Gouache	59	-2	3	12,2
6 Gesso + Rabbit S. Glue	Mastic resin	64	2	5	12,8
9 CaCO3 + Mowilith	Mastic resin	62	0	3	13,2
20 Modostuc	Gouache	60	-3	3	13,1
10 Gesso + Mowilith	Watercolor	64	0	4	13,8
16 Gesso + Plextol	Watercolor	58	0	2	12,1
18 Gesso + Plextol	Mastic resin	60	1	2	12,7
19 Modostuc	Watercolor	61	0	2	13,4
2 CaCO3 + Rabbit S. Glue	Gouache	63	-2	3	14,4
5 Gesso + Rabbit S. Glue	Gouache	60	-2	2	13,5
11 Gesso + Mowilith	Gouache	61	-2	2	14,0
15 CaCO3 + Plextol	Mastic resin	59	-1	-1	15,4
13 CaCO3 + Plextol	Watercolor	57	-1	-1	14,9
Measurement on the painting		54	+ 3	+ 13	

According to the results above, we can recognize that sample number 21 presents the lowest ΔE value, and through this criterion, it can be selected for the real case intervention at the painting.

3.1 Selection from the "pigmented fillers" group of samples

Below we can see (Figure 8) the FORS spectra from the eight samples prepared on a lightness scale, with a controlled addiction of pigments.

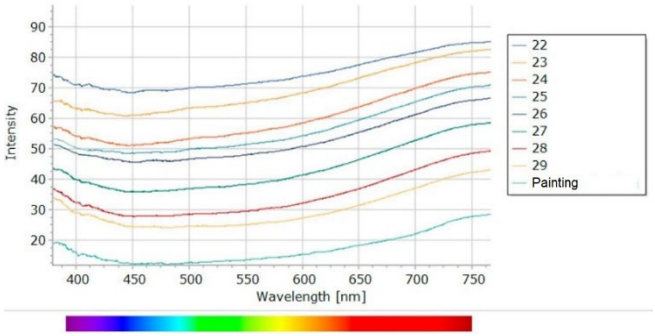

Figure 8 – FORS results from pigmented fillers compared to the measurement at the painting.

As we can see, there is a similarity between the spectra obtained at the samples and the one obtained at the painting.

But to quantify this similarity, a complementary technique, colorimetry is necessary once the comparison between the spectra is merely qualitative.

The comparison through ΔE calculation follows:

Table 2 – ΔE results from samples 22 to 29, compared to flesh tone at the painting.

CIE Lab color measurement - Masses pigmented on laboratory				
Sample	Lightness	- a +	- b +	ΔE
22	70	-6	-4	25,0
23	69	-8	-4	25,2
24	64	-4	-1	18,6
25	62	-3	-1	17,2
26	62	-2	-2	17,7
27	60	-1	+2	13,2
28	54	+1	+5	**8,2**
29	48	+2	+6	9,3
Painting measurement	54	+3	+13	

We can conclude that the most similar sample is #28. Still, due to the changes on saturation and lightness after varnish application above the mass, it will be chosen the lightest one, sample #27, assuming this darkening is sure to occur due to Modostuc properties.

At Veloso Salgado painting, sample #27 will be applied close to the sample #21 but on separated losses, and to a final comparison, a visual evaluation will be done together with a FORS measurement on both reintegration areas.

3.2 Intervention at the painting with the chosen samples 21 and 27

With the selection of the samples made, an intervention was executed at a selected area at some paint losses. The chosen area was located at the right leg, according to Figure 9.

Figure 9 – Zones of chromatic layer loss at the right leg (A) selected for the real case intervention with samples 21 (detail B) and 27 (detail C).

The filling materials and the varnish were applied at the zones of loss. It was used Laropal A81 due to the good photochemical stability [12] and brightness compatibility with the original surrounding surface. The final aspect follows below (Figure 10).

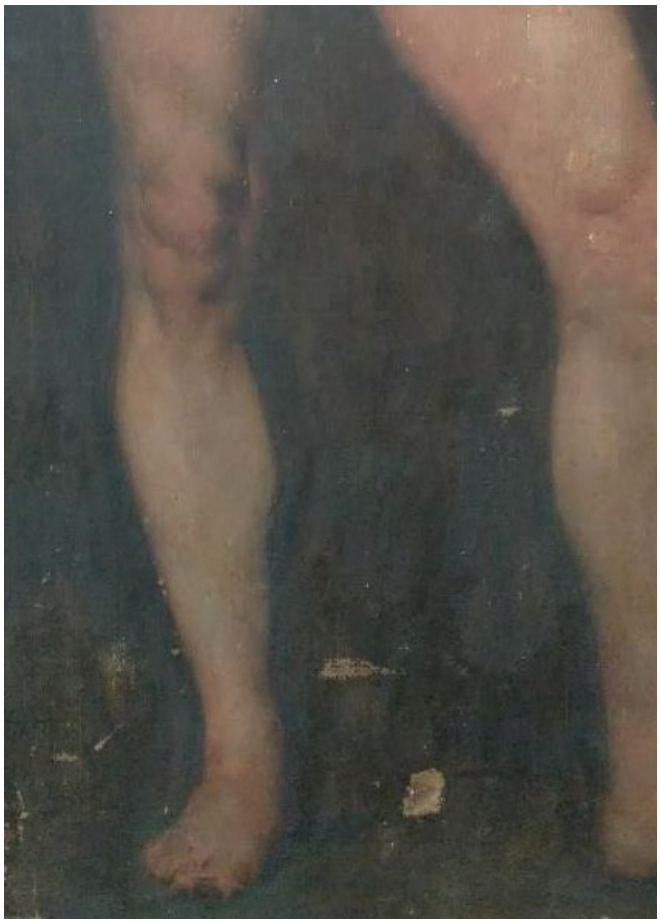

Figure 10 – Final aspect from the intervention with the selected masses.

3.3 Comparison between the final interventions with FORS

FORS was used after the intervention to compare the reintegration result with the one obtained at a near zone of the original flesh tone.

Below we can see both spectra (Figures 11 and 12):

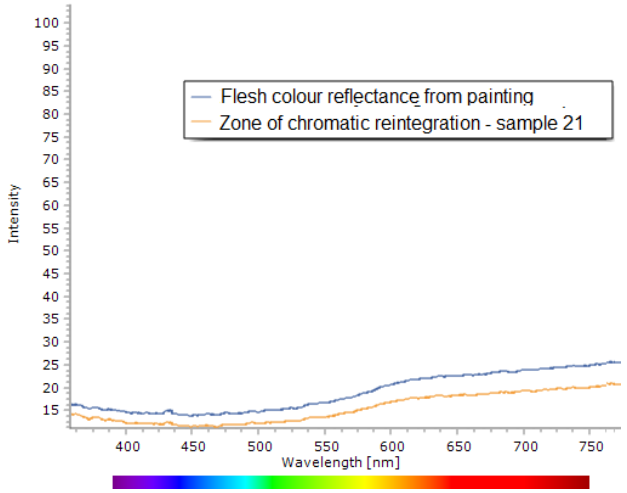

Figure 11 – Comparison between FORS measurements obtained on flesh color area at the painting and the nearest chromatic reintegration zone with sample 21 from the mockup.

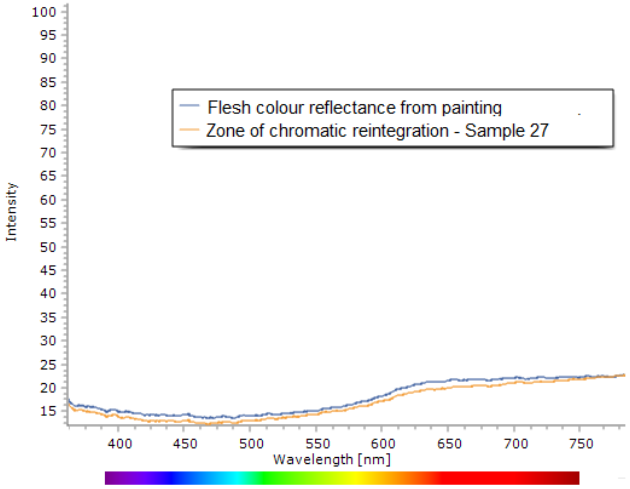

Figure 12 – Comparison between FORS measurements obtained on flesh color area at the painting and the nearest chromatic reintegration zone with the sample 27 from the mockup.

As we can see, reintegration made with sample 27 (a colored mass with controlled addition of pigments) achieved a better agreement with the visible light reflectance spectrum from the original painting.

4. LIST OF MATERIALS USED

- Calcium Carbonate ($CaCO_3$) from Kremer Pigment.
- Gypsum ($CaSO_4.H_2O$) from Inart.
- Natural binder: Rabbit Skin Glue from R&C.
- Synthetic binders:

Mowilith DS 5/2 from Celanese, and Plextol B500 from Synthomer.

- Ready-made putty: Modostuc Bianco, from GIMOD.
- Paintings:

Watercolor from Winsor&Newton Professional Line, tones Titanium White (PW6), Yellow Ochre (PY43), Indian Red (PR101) and French Ultramarine (PB29).

Gouache from Talens Extra Fine Quality, tones Titanium White (PW6/PW5), Yellow Ochre (PY42), Vermillion (PR4), Light Ultramarine Blue (PB29).

Maimeri Restauro Varnish Colors, tones Titanium White (PW6/PW4), Yellow Ochre (PY43), Cadmium Red Medium (PR108) and Ultramarine Blue (PB29).

- Pigments: Ferrario Color, tones Burnt Umber (PBr7) and Raw Sienna (PY43).

5. CONCLUSIONS

We conclude that the combined use of FORS and colorimetry was suitable to detect differences between several filling materials formulations at the mockup and at an original zone in the case study painting.

Also, the combined use of these techniques allowed us to choose the most similar color and execute a more safe and time saving chromatic reintegration procedure.

Pigmented fillers for chromatic reintegration appeared to be a suitable methodology for contemporary art considering that many of the easel paintings on a contemporary concept of production do not present a final varnish layer.

Also, the use of pigmented fillers simplifies the retouch process. The combined methodology of FORS and colorimetry allowed minimal use of different pigments. In this way, we can reduce unpleasable results. Color alteration through time and other problems, like metamerism, can also be minimized.

A smartphone is also a low-cost resource, available to every conservator-restorer. The application selected presented good correlation results between the samples themselves and became a good strategy when this kind of comparison was demanded, with low financial investment.

REFERENCES

[1] VILLARQUIDE, A. (2005). *La pintura sobre tea II. Alteraciones, materiales y tratamientos de restauración.* San Sebastián: Nerea, p. 361.

[2] FUSTER-LÓPEZ, L. (2008). *El estuco en la restauración de pintura sobre lienzo.* Valencia: Editorial de la UPV, p. 18.

[3] APPLEBAUM, B. (2007). *Conservation treatment technology.* Burlington: Elsevier, p. 329.

[4] BAILÃO, A. (2011). As técnicas de reintegração cromática na pintura: revisão historiográfica. *Ge-Conservación.* 2, 45-63.

[5] CARDEIRA, A. (2014). Caracterização material e técnica das "Académias de Nu" de José Veloso Salgado, pertencentes à colecção da FBAUL. Lisboa: Faculdade de Belas-Artes da Universidade de Lisboa. Dissertação de Mestrado em Ciências da Conservação, Restauro e Produção de Arte Contemporânea, p. 14.

[6] FERRAZ, A. (2017). Materiais e Técnicas da Pintura a Óleo em Portugal (1836-1914): Estudo das fontes documentais. Lisboa: Faculdade de Ciências e Tecnologia, Universidade NOVA de Lisboa. Tese de Doutoramento em Conservação e Restauro do Património, p. 143.

[7] AGUIAR, M. (2012). Os materiais e a técnica de pintura a óleo na obra de Aurélia de Souza e a sua relação com a conservação. Porto: Escola das Artes, Universidade Católica Portuguesa. Tese de Doutoramento em Conservação de Pintura, p. 119.

[8] BACCI, M. (1995). Fibre optics applications to works of art. Sensors and actuators – B, 29, p. 190.

[9] WESS, T. (2017). Smartphone citizen science: Can a conservation hypothesis be tested using non specialist technology? Heritage Science, 5, 1, pp. 35-46.

[10] VILLARQUIDE, A. (2004). La pintura sobre tela I. Historigrafía, técnicas y materiais. San Sebastián: Nerea, 2004, p. 64.

[11] CRUZ, A. (2007). A cor e a substância: sobre alguns pigmentos mencionados em antigos tratados portugueses de pintura - pigmentos amarelos. ARTIS – Revista do Instituto de História da Arte da Faculdade de Letras de Lisboa. 6, p. 156.

[12] LEONARD, M. et al. (2012). Development of a new material for retouching. Studies in Conservation. 45, 1, p. 111.