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The Use of TRI-Funori® as a Binding Medium for Chromatic Reintegration in Contemporary Unvarnished Paintings

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——— Each material is suited to the different paint material characteristics and pictorial techniques of various artworks by contributing to the pictorial surface's stability and visual unity, and the ability to display it without interruption. For this article, the polysaccharide TRI-Funori was tested and used as a binding medium for chromatic reintegration in three oil and acrylic mockups of the artwork by Portuguese artist Jorge Martins. This choice was based on characteristics such as compatibility, low toxicity, water-based properties, and good visual properties for color matching. Advantages such as transparency and less tendency to yellow, capacity to dry matte, and ease of removal were observed. It presents good dispersion of inorganic pigments, good visual properties, and good adhesion to oil and acrylic surfaces with or without preparation. However, it also presents disadvantages such as weak dispersion of organic pigments, for example [PB15] Phthalocyanine Blue or [PR83] Carmine Rose, and the tendency to become powdery. During the drying process, it tends to lighten, making the color adjustment process difficult.

The mimetic method, achieved with small dots, was used for retouching. The medium was applied with Ferrario® *pigmenti puri* and Winsor & Newton® powdered pigments, and chromatic reintegration was carried out with a fine brush Winsor & Newton® Finest Sable nº1.

Keywords: chromatic reintegration, TRI-Funori, unvarnished paintings, contemporary painting, color matching, organic pigments.

1.
Mockup 1, 2, and 3. Mockup 1 and 2 are painted with oil on linen, Mockup 3 (the rightmost) painted with acrylic on linen, photo by Marta Aleixo, 2017–2020

Introduction

Chromatic reintegration as well as *inpainting* or *retouching* have importance in the process of reintegrating color[1] and contribute to the pictorial surface's stability, visual unity, and the ability to display without interruption. This process should always be based on the concept of minimal intervention by respecting the artwork's value and materials.

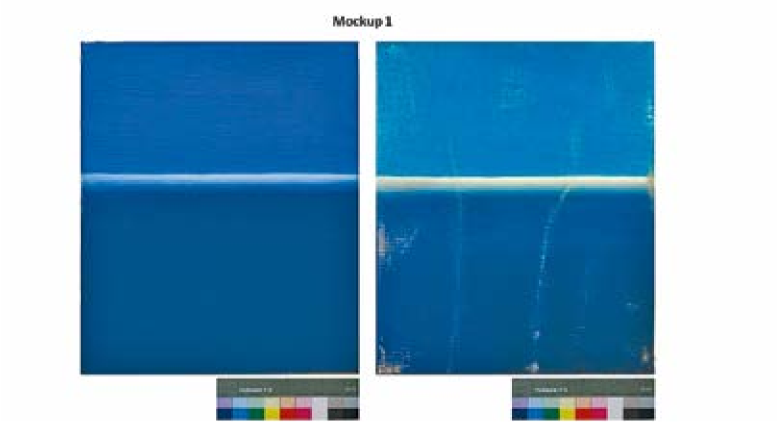
A large variety of materials exist that can be used to perform chromatic reintegration. These materials can be aqueous, non-aqueous, or dry. Their properties can be natural, synthetic, or semisynthetic, prepared manually or purchased commercially.[2]

This article provides information about the polysaccharide TRI-Funori®[3] used as a binding medium with powdered pigments for chromatic reintegration in three contemporary oil and acrylic unvarnished paintings [fig. 1]. Polysaccharide use is not new among conservators and restorers. However, its use as a binding medium is still uncommon. Its application

1 Antonio Iaccarino Idelson, Leonardo Severini, "Inpainting", in *The Encyclopedia of Archeological Sciences* (John Wiley & Sons, Inc., 2018), 1–4, doi:org/10.1002/9781119188230.saseas0330; Ana Bailão, "O sistema das nove cores na reintegração cromática de bens culturais", *Ge-conservacion*, vol. 5 (2013): 110–134, doi:org/10.37558/gec.v5i0.171.

2 Ana Bailão, Liliana Cardeira, "Mixing and Matching. A survey of retouching materials", in *4th International Meeting on Retouching of Cultural Heritage, RECH 4* (2017), 248–255.

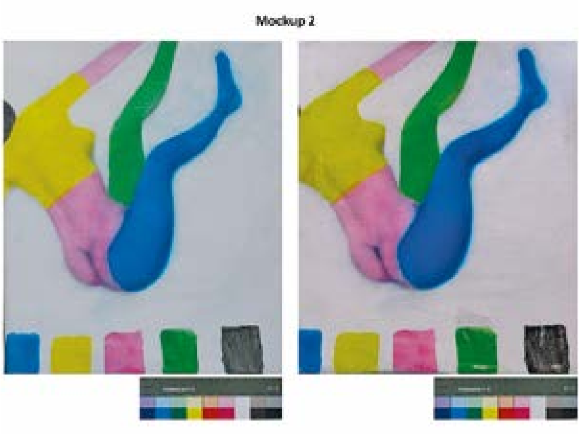
3 Marta Aleixo, Ana Bailão, Andreia Gomes, João Linhares, Margarita San Andrés, and Sérgio Nascimento, "Chromatic Reintegration in Contemporary Monochromatic Unvarnished Paintings: a case study based on artwork from Jorge Martins", *Ge-Conservacion*, vol. 18 (2020): 328–338, doi:org/10.37558/gec.v18i1.817.



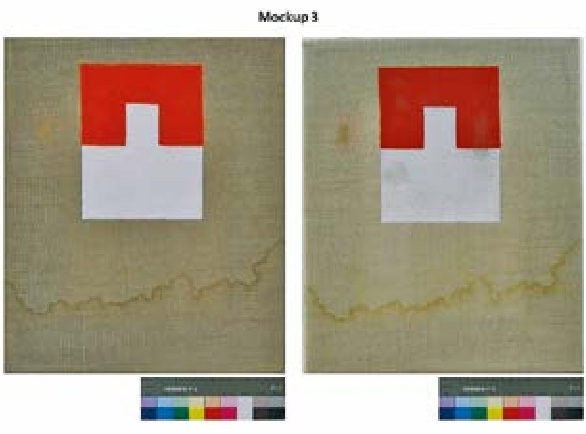
2.
Before and after damage and aging simulation on Mockup 1, photo by Marta Aleixo, 2017–2020

was based on an experimental test developed as part of a master's project (2016–2019) focused on the study of materials for chromatic reintegration on unvarnished paintings by the Portuguese artist Jorge Martins (1940). For this purpose, several oil and acrylic works by the painter were studied, as well as his pictorial techniques. The process was developed through a face-to-face interview with the artist, visits to his atelier, observation of his works, and a collection of his materials.

One of the main characteristics present in Jorge Martins's painting is the fact that the artist does not varnish his paintings. This particularity increases the risk of damage, such as abrasions and detachment of the chromatic layer [figs. 2–4]. To study possible solutions both for this type of damage and for suitable chromatic reintegration materials, mockups were created with the artist's help. On these models, we simulated detachments of the chromatic layer followed by artificial ageing (500h) to gain a lifespan similar to the artist's original paintings (between 60 to 70 years old), which served as a reference for their creation. For the artificial ageing, a Suntest XXL + Atlas camera was used and the values of the ASTM D model 4303-03349 were adopted, with radiation from 300nm to 400nm in an energy range of 60, 5W/m2, and at a temperature of 60°C.



3.
Before and after damage and aging simulation on Mockup 2, photo by Marta Aleixo, 2017–2020



4.
Before and after damage and aging simulation on Mockup 3, photo by Marta Aleixo, 2017–2020

During the investigation process, we planned several tests on the mockups using the most common materials for chromatic reintegration.[4] Among them, the polysaccharide TRI-Funori® appeared the most appropriate. In selecting this polysaccharide, we considered:

• The solubility of the pictorial layer, since the wrong choice of materials for chromatic reintegration can solubilize the chromatic surface,[5] causing irreversible damage;

4 Ana Bailão, and Liliana Cardeira, "Mixing and Matching. A survey of retouching materials", in *4th International Meeting on Retouching of Cultural Heritage, RECH 4*, ed. Ana Bailão and Sandra Sustic, 248–255 (Croatia: Academy of Arts, University of Split, 2017).

5 Klaas Jan van den Berg, Aviva Burnstock, Jay Krueger, Tom Learner, and Gunnar Heydenreich. *Issues in Contemporary Oil Paint* (Springer, 2014), doi:org/10.1007/978-3-319-10100-2; Bronwyn Ormsby and Tom Learner, "Artists' acrylic emulsion paints: materials, meaning and conservation treatment options". *AICCM Bulletin*, 34:1 (2013), 57–65, doi:org/10.1179/bac.2013.34.1.007.

- Compatibility;
- Stability of the material;
- Removability;
- Their water-based properties;
- Toxicity;
- The novelty of the material as a binding medium.

Due to the importance of color in contemporary surfaces, we also considered color matching, the visual properties during paint preparation and chromatic reintegration, and possible changes during the drying process.

What is TRI-Funori®?

TRI-Funori® is derived from Funori®,[6] a polysaccharide starch extracted from red algae from the coast of Japan, namely *Gliopeltis tenax* (*ma-funori*), *Gloiopelties complanate* (*hana-funori*), and *Gliopelties furcata* (*fukuro-funori*).[7] These three species are known as funorans.

The use of Funori is not new in the conservation and restoration field, being part of Japanese conservation and restoration tradition and artistic practices. The use of polysaccharides, popularized internationally by conservators and restorers in various fields, has been applied in architecture, paintings, or paper conservations as a glue, as a consolidant, as an adhesive,[8] as a cleaning agent, and more recently as a binding medium.

As a natural product, Funori and its variants also have variable quality (which has been improved over the years). The Institute for the Preservation of Monuments and Historic Buildings of the Swiss Federal Institute of Technology Zurich (ETH), the Swiss Federal Research Institution for Materials Science and Technology (EMPA), and the Conservation Centre of the Swiss National Museum have come together to produce a

6 Charles Velson Horie, *Materials for Conservation. Organic consolidants, adhesives and coatings* (Oxford: Butterworths, 2010).

7 Leonardo Borgioli, "CTS Webinar 5 (IT) – Funori. CTS Europe", YouTube, 2020, https://www.youtube.com/watch?v=4iJCGCfMO_U&ab_channel=CTSEUROPE.

8 Joseph Swider and Martha Smith, "Funori: Overview of a 300-year-old consolidant", *Journal of the American Institute for Conservation*, AIC, 44, no. 2 (2005): 117–26, http://www.jstor.org/stable/40025138; Jillian Harrold and Zofia Wyszomirska-Noga, "Funori: The use of a traditional Japanese adhesive in the preservation and conservation treatment of Western objects", *Adapt & Evolve 2015: East Asian Materials and Techniques in Western Conservation*, proceedings from the International Conference of the Icon Book & Paper Group Conference London 8-10 April 2015, 69–79 (London: The Institute of Conservation, 2017), https://onlinelibrary.wiley.com/doi/epdf/10.1002/9781119188230.saseas0330.

standardized product called JunFunori®. Its purified form, ("Jun" means "pure"), is manufactured exclusively by Lascaux® and made available by AP Fitzpatrick®.

JunFunori and its tendency to yellow[9] led to the introduction in 2012 of purified and dehydrated alternatives called TRI-Funori. The purified version is composed of a water-based polysaccharide starch mucilage extracted from raw, unpurified Funori.

The properties of both variations are similar. For example, both dry matte. However, TRI-Funori®[10] is more stable and has less tendency to yellow. TRI-Funori presents the following characteristics:

- Binds larger quantities of water for its mass without wetting the surface;
- Does not mobilize salts and therefore does not leave tide lines on pictorial surfaces;
- Can be reactivated and solubilized (removed) with the addition of distilled water;
- Is a low-viscosity material and works at low concentrations;
- Has a better quality, more stable properties, and longer-lasting characteristics and performance.

There are three different types of TRI-Funori: TRI-Funori FD, TRI-Funori S and TRI-Funori L. For the experiment, we used TRI-Funori FD, in which the seaweed is chopped and cooked after the sun bleaching.[11]

Methodology

The process of color matching during the preparation of the paint for chromatic reintegration was developed based on the decomposition of the color and pigments on the original paintings. For chromatic reintegration, powder *pigmenti puri* from Ferrario® and Winsor & Newton®

9 Shelley Simms, Maureen Cross, and Patricia Smithen, "Retouching for Acrylic Paintings", *Mixing and Matching. Approaches to Retouching Paintings* (London: Archetype Publications, 2010), 163–179.

10 *Technical Data Sheet TRI-Funori*™ (Canada, 2015), https://www.historicplaster.com/wp-content/uploads/2021/01/TRI-Funori-technical-data-sheet-6-April-2015.pdf; *Technical Data Sheet Lascaux TRI-Funori. LASCAUX*® (2016), https://lascaux.ch/dbFile/4706/u-5477/Lascaux_TRI-Funori_e.pdf.

11 *Technical Data Sheet TRI-Funori*™ (Canada, 2015), https://www.historicplaster.com/wp-content/uploads/2021/01/TRI-Funori-technical-data-sheet-6-April-2015.pdf; *Technical Data Sheet Lascaux TRI-Funori. LASCAUX*® (2016), https://lascaux.ch/dbFile/4706/u-5477/Lascaux_TRI-Funori_e.pdf.

pigments were used, and a white base using the Winsor & Newton® Titanium White [PW6] pigment was first applied. To tone the darkest spots left by abrasions in the linen, we had to apply a white base. The paint used was gouache [PW6] Titanium White from Winsor & Newton® Designers Gouaches.

Given the dimensions and location of the abrasions, chromatic reintegration was punctual and performed with the mimetic method. It was achieved with small dots, avoiding the creation of visual patterns and the alteration of color perception that could occur with the use of other chromatic reintegration techniques.

Before preparing the paint, following the manufacturer's instructions, the TRI-Funori FD was re-hydrated by adding it to distilled water at a ratio of 1 part TRI-Funori FD to 100 parts water by weight. It was then stirred vigorously for 15 minutes over a hot water bath at 50ºc. After rehydrating, the TRI-Funori was further diluted with distilled water at 1% (v/v).

The preparation of the paint – the pigment powder plus the TRI-Funori – was done on a palette, after performing different tests on surfaces identical to those of the paintings. Since we knew what paints were used during the creation of the mockups, it was easier to define the palette used to perform the chromatic reintegration. Table 1 presented, below, shows the range of pigments selected to perform chromatic reintegration.

Table 1. Pigments selected for chromatic reintegration palette.

CHROMATIC REINTEGRATION PIGMENTS	
Ferrario® pigmenti puri	Winsor & Newton® pigments
Cadmium Yellow Deep [PY37] Organic Orange [PO13] Cadmium Yellow Orange [PO20] Cadmium Red Light [PR108] Cerulean Blue [PB35] Ferrario Blue [PB15] Ultramarine [PB29] Titanium White [PW6] Ivory Black [PBk9]	Lemon Yellow [PY3] Camine Fine [PR83]

Oil mockups 1 and 2

Mockup 1 represented a monochrome surface with three main colors, here one light blue, one deep blue, and one white, presented in Table 2.

For the light blue, we created a pigment mixture in which [PB35] Cerulean Blue formed the base of the color. Because it was the dominant color and had strong properties such as opacity, we added [PB15] Ferrario Blue pigment, which conferred luminosity and transparency to the paint mixture through its strong color tint [table 2]. The deep blue of the mockup constituted a warm blue composed of pigments [PB60] Idantrene Blue and [PB15:6+PB29, PNk9] Indigo. To achieve proper color matching, the deep blue mixture was divided into three steps, in which it was necessary to define the exact proportions to create the full mixture. The first step consisted of mixing the pigments Cerulean Blue [PB35] (dominant color) and Ultramarine [PB29] (to darken the paint mixture by giving it a red tint).

In the second step, we added another mixture. To decrease the saturation and to darken the blue tone obtained in the first mixture, we added the pigment Marigold Orange [PO73]. Lastly, to give the pigment transparency, we added as the third step Phthalocyanine [PB15]. By adding the pigment Ferrario Blue we achieved a closer blue to the paint; however, this pigment has a strong tinting power. By using pigment [PO13] we cut and controlled the color saturation while keeping a harmonious deep blue.

Table 2. Description of pigments and proportions used in Mockup 1.

MOCKUP 1		
Colours/areas reintegrated	**Original paints**	**Chromatic reintegration pigments**
Light Blue	[PB15:4, PW4] Sèvres Blue Rembrandt, Royal Talens® (+ [PB74] Cobalt Blue)	[PB15] Phthalocyanine Blue (+ [PB35] Cerulean Blue) Ferrario® pigmenti puri
Light blue final mixture:	0.95g [PB35] Cerulean Blue + 0.5g [PB15] Ferrario Blue	
White	[PW6] Titanium White Rembrandt, Royal Talens®	PW4 Titanium White, Winsor & Newton® Designers Gouache

Deep Blue	[PB60] Idantrene Blue, Winsor & Newton® + [PB15:6, PB29, PBk9] Indigo Rembrandt®, Royal Talens®	[PB29 Ultramarine Blue] + PB15 Phthalocyanine Blue] + PO13 Organic Orange (+PB35 Cerulean Blue) Ferrario® pigmenti puri
Deep Blue final mixture:	(0.5g [PB35] Cerulean Blue + 0.95g [PB29] Ultramarine) + (0.5g [PB35] Cerulean Blue (color base) + 0.95g [PB29] Ultramarine] + 0.3g [PB15] Ferrario Blue + [PO13] Organic Orange)	

Both mixtures, light and darker blue, were not always identical. Depending on the areas to be reintegrated, a color adjustment was made with the addition of one of the pigments that make up the mixture.

Mockup 2 did not require complex mixtures since most of the colors used were pure [table 3], and they were relatively easy to apply when mixed with TRI-Funori. The only color mixing required to be carried out was for the creation of the color green. Pigments [PY3] Lemon Yellow and [PB15] Ferrario Blue from Ferrario® *pigmenti puri* were used. In this case, pigment [PY3] Lemon Yellow, which has a green tone tendency, conferred luminosity, and pigment [PB15] Ferrario Blue conferred the transparency and cool tonal bias[12] that characterized the original green present in the mockup.

Table 3. Description of pigments and proportions used in Mockup 2.

MOCKUP 2		
Colors/areas reintegrated	**Original paints**	**Chromatic reintegration pigments**
Pink	[PV19] Quinacridone Rose, Rembrandt®	[PR83] Carmine Fine Winsor & Newton®

12 Ana Bailão, „O sistema das nove cores na reintegração cromática de bens culturais", *Ge-conservacion*, vol. 5 (2013): 110–134, doi:org/10.37558/gec.v5i0.171.

White	[PW6] Titanium White Rembrandt, Royal Talens®	[PW4] Titanium White Ferrario® *pigmenti puri*
Yellow	Cadmium Yellow Medium, Sennelier®	[PY3] Lemon Yellow Winsor & Newton®
Green	[PB15] Winsor Blue Green Shade, Winsor & Newton®/ [PB15] Winsor Blue Green Shade, Winsor & Newton® [PY35] Cadmium Yellow Medium Sennelier® + [PB15: 3 PG7] Touareg Blue, LeFranc®	[PY3] Lemon Yellow + [PB15] Ferrario Blue Ferrario® *pigmenti puri*
Blue	[PB15] Winsor Blue Green Shade, Winsor & Newton® + [PB15, PW6] Sèvres Blue, Rembrandt®	
Black	[PBk9] Ivory Black®, Winsor & Newton®	[PBk9] Ivory Black

Acrylic mockup 3

To achieve an approximation of the tone and luminosity of the opaque inorganic pigment, we used a mixture of two colors. Red was the basis of the original pigment, while orange, in greater quantities, added luminosity and brightness to the tone, giving it a lighter color during chromatic reintegration as a result [table 4]. The adjustment was made with either red or orange, depending on the surrounding color area.

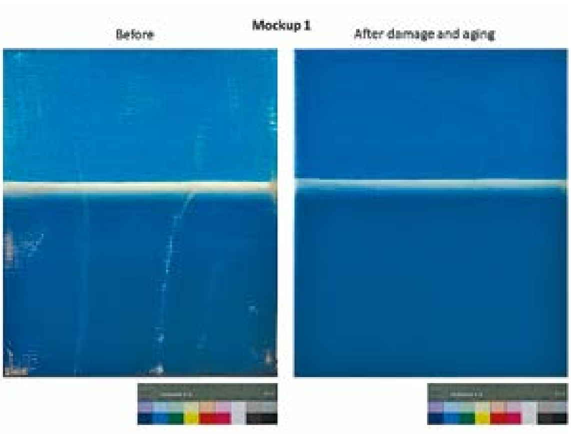
Table 4. Description of pigments and proportions used in Mockup 3.

MOCKUP 3		
Colors/ areas reintegrated	**Original paints**	**Chromatic reintegration pigments Ferrario® *pigmenti puri***
White	[PW6] Titanium White, Winsor & Newton®	[PW4] Titanium White
Red	[PR108] Cadmium Red Light, Winsor & Newton®	[PO20] Cadmium Yellow Orange Ferrario® *pigmenti puri*
Red final mixture	0.80g [PO20] Cadmium Yellow Orange + 0.20g [PR108] Cadmium Red Light	

Discussion

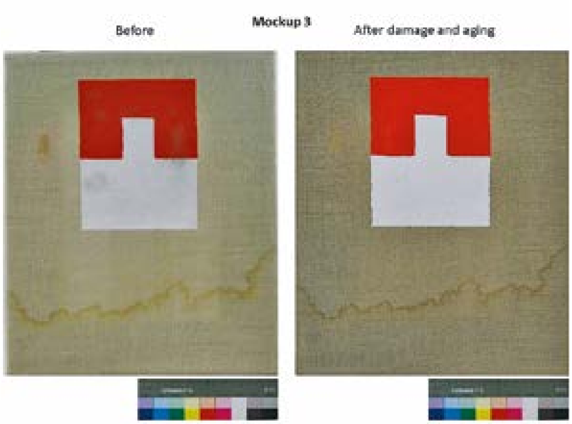
During the color preparation and the drying process, we observed a tendency for the color to become lighter when mixed with TRI-Funori. However, knowing the original color proportions made the process of color matching easier since we could predict the results of the color mixture. The color adjustments for mockups 1 and 3 were made with the addition of one of the pigments that make up the original mixture to take into account the tonal variations on the paintings' surfaces. The effect of the chromatic reintegration can be seen in the examples of mockups [figs. 5–7].

Although the preparation of paints with TRI-Funori has positive features, such as the fact that it is a natural material and that it dries matt (a relevant characteristic for unvarnished paintings), it also presented some disadvantages. Since it is water-based, its properties interfered with organic pigment dispersion such as pigment [PB15] Ferrario Blue (originally the phthalocyanine pigment) and pigment [PR83] Carmine Fine. Chromatic interventions become powdery over time. In the case of Mockup 1, it had to be removed by swabbing using water in areas of both light and deep blue.



5.
Mockup 1 before and after chromatic reintegration, photo by Marta Aleixo, 2017–2020

6.
Mockup 2 before and after chromatic reintegration, photo by Marta Aleixo, 2017–2020



7.
Mockup 3 before and after chromatic reintegration, photo by Marta Aleixo, 2017–2020

Chromatic reintegration was then repeated, using this time Winsor & Newton® Designers Gouaches. Although Mockup 2 was also reintegrated with organic pigments, they did not need to be removed. Mockup 3 did not present any problems after chromatic reintegration, not even during the dispersion of the pigments in the preparation of the paints.

The origin of these problems found during the preparation of the paints may be related to the quality of the pigments, the presence of the element copper, and their interaction with the TRI-Funori, as well as the quantity of water and TRI-Funori used in these preparations. The substrates of the paintings may also have influenced the adherence of the paint to the substrates. Hence, in Table 5 we present the advantages and disadvantages of this binding medium:

Table 5. Advantages and disadvantages of the polysaccharide TRI-Funori.

TRI-FUNORI	
ADVANTAGES	**DISADVANTAGES**
Low viscosity pH neutral Dries matte Chromatic reintegration tends to become lighter when dried Easily removable and nontoxic	Weak dispersion of organic pigments: PB15 phthalocyanine blue (presence of cooper) Weak adhesion on some paint substrates Some difficulty in color matching Expensive material

Conclusion

Reintegration materials and their behaviors are all different. This work presented a specific case study for which mockups were developed to test different materials for chromatic reintegration. The aim was to find materials that could be used for unvarnished oil and acrylic paintings. Among other materials, such as Winsor & Newton® Designers Gouache, TRI-Funori® presented good visual properties.

Some of the main advantages of TRI-Funori are the ecological factor, its solubility in water, and its matte properties. Even considering the dispersion problems with organic pigments, it presented good visual results as a material for chromatic reintegration in these specific unvarnished, matte oil and acrylic paintings. The polysaccharide also presented difficulties during color matching since it dries lighter. However, this could be viewed as an advantage since chromatic reintegration was carried out with the mimetic method, which tends to darken over time. The problem of color can be mitigated by balancing the level of saturation and the luminosity of the hues used, leaving the chromatic reintegration lighter than the surrounding area of the original layer.

The main disadvantage of the binder was the difficulty observed during the paint preparation process, which proved to disperse some pigments better, to the detriment of others.

Work quality will always depend on the surface the paint is applied to, its durability, and the conditions that paintings will be subjected to, since both the polysaccharide and oil and acrylic paintings are susceptible to damage from humidity and temperature.

These experiments were developed through practical tests, both on mockups and on similar surfaces to the mockups. The visual properties and quality of the materials were evaluated through visual inspection and using colorimetry (hyperspectral imaging). These interventions represent an experiment and not a possible solution. More investigation into the properties and durability of TRI-Funori is needed for a better understanding of the material and its behavior when used as a binding medium. Each case must be evaluated individually.

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Santrauka

TRI-Funori® kaip rišančiosios terpės naudojimas spalvinei reintegracijai šiuolaikiniuose nelakuotuose paveiksluose

Marta Aleixo, Ana Bailão

Reikšminiai žodžiai: spalvinė reintegracija, TRI-Funori, nelakuoti paveikslai, šiuolaikinė tapyba, spalvų derinimas, organiniai pigmentai.

Kiekviena medžiaga yra pritaikyta prie skirtingų dažų medžiaginių savybių ir kūrinių vaizdavimo technikų, taip paveikslo paviršiui suteikiant stabilumo ir vizualinės vienovės, leidžiant jį tinkamai ir netrikdomai apžiūrėti. Atsižvelgiant į minimalios intervencijos ir pagarbos meno kūrinio vertei ir medžiagoms koncepciją, tinkamos medžiagos parinkimas spalvinės reintegracijos intervencijai šiuolaikinėje tapyboje yra sudėtingas uždavinys, ypač jei paveikslų vaizdo paviršius yra nelakuotas.

Šiame straipsnyje aprašomas *TRI-Funori*® polisacharido, kaip spalvinės reintegracijos rišiklio, naudojimas. Jis buvo išbandytas ant portugalų menininko Jorge Martinso trijų aliejinės tapybos ir trijų akrilo tapybos paveikslų. Šio rišiklio pasirinkimą nulėmė tokios savybės kaip suderinamumas, mažas toksiškumas, vandens pagrindas ir geros vizualinės spalvų derinimo savybės.

Atliekant spalvų reintegracijos testus, geriausių rezultatų buvo gauta naudojant *Ferrario*® ir *Winsor & Newton*® pigmento miltelius, išsklaidytus *TRI-Funori*® vandens terpėje.

TRI-Funori®, nors išdžiūvusi tampa visiškai matinė, davė gerų vizualinių rezultatų kaip reintegruojamoji medžiaga tiek ant aliejinės tapybos, tiek ant akrilo paviršių. Pagrindinis rišiklio trūkumas buvo pastebėtas ruošiant dažus – naudojant neorganinius pigmentus, rišiklis pasiskirstydavo geriau. Atliekant bandymus ir tyrimus taip pat pastebėta, kad medžiagoje agliutinuoti organiniai pigmentai po tam tikro džiovinimo laiko linkę

porėti. Šis veiksnys yra susijęs su naudojamų pigmentinių miltelių kokybe ir savybėmis, taip pat su rišikliu, dispersijos sąlygomis ir grunto, ant kurio tepami dažai, tipu. Taip pat pastebėta dažų šviesėjimo tendencija, turėjusi įtakos spalvų derinimo procesui tiek atlikimo metu, tiek išdžiūvus reintegracijai. Ši savybė taip pat būdinga kai kurių rūšių guašui ir priešinga kai kurių rūšių akvarelei, kuri yra linkusi tamsėti.