

A NEW PIGMENTED WAX-RESIN FORMULATION FOR INFILLING AND REINTEGRATING LOSSES IN PAINTINGS: TESTING ITS WORKABILITY IN TWO CASE STUDIES

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ABSTRACT

A new pigmented wax-resin formulation introduced and tested for its suitability as a material to infill and reintegrate losses in paintings. This formulation contains Cosmoloid H80 microcrystalline wax and Regalrez® 1126 hydrogenated hydrocarbon resin, in a ratio of 1.5:1 (wax:resin, parts by weight), and is mixed with dry pigments and/or inert fillers (such as chalk, kaolin, or aluminium hydroxide).

After extensive research on the properties and the stability of various formulations, the most successful one was applied on two canvas paintings with very diverse characteristics: a 17th century oil painting, and a 21st century acrylic painting.

In this paper, the different application methods used are described step-by-step. These consisted of using the new formulations not only solely as infilling materials (by adding inert fillers to the wax-resin mixture), but also as materials capable of infilling and reintegrating a loss in one single step (by adding pigments to the wax-resin mixture). The possibility of imprinting and carving texture, as well as of sculpting the infills to recreate brushstrokes, was also tested and verified and is described in detail here.

Keywords: Pigmented wax-resin; Cosmoloid H80; Regalrez® 1126; infilling; reintegration; workability

1. INTRODUCTION

1.1 Pigmented wax-resin (PWR) formulations and their advantages as materials to infill and reintegrate losses in paintings

PWR formulations have been used to infill and reintegrate losses in paintings and other objects at least since the 18th century [1]. These formulations consist of mixtures of a wax and a resin, to which dry pigments and/or inert fillers are added.

The possibility of adding pigments directly to the wax-resin (WR) mixture is a significant advantage for it enables infilling and colour reintegration to be done in a single step, which can be especially useful for monochromatic surfaces. An accurate and quick colour match is possible since hues do not change as the mixture transitions from warm (fluid) to cool (solid) states. Where required, PWRs can also accept surface adjustments with glazes using different inpainting media. Additionally, a more traditional method of reintegrating losses is possible, as the WR mixture, with the addition of chalk or pigments, can be used as a neutral or toned base over which further layers of inpainting can be applied using an appropriate resin based retouching medium.

PWRs need to be melted prior or during application. They can, however, be applied in layers, allowing for an easy, controlled introduction into the loss. They will

also remain workable if warmed up, for example with a small heated spatula, facilitating sculpting of brushstrokes or other topographical features.

Another advantage of PWRs lies in their ability to receive texture (e.g., using silicone moulds to imprint craquelure or canvas weave patterns). They are easily removable mechanically or with low-aromatic solvents, such as white spirits, during and after application.

Where required, gloss can be adjusted: to achieve a high gloss, PWR infills can be polished with a soft cloth, while rendering them matte can be done with solvents or burnishing with matte, silicone or wax coated paper.

1.2. Finding a substitute for beeswax in PWR formulations

One of the most common materials present in traditional PWR formulations, produced either by conservators themselves or, more recently, by Gamblin Conservation Colors [2], is beeswax. Beeswax has, however, been reported to develop bloom (a thin whitish layer on the surface that changes its readability) [3] and to corrode copper supports used for oil paintings [4, 5].

Finding an appropriate replacement material for beeswax which could be combined with a stable synthetic resin, became the core of recent studies conducted at the NOVA School of Science and Technology (Lisbon, Portugal) [5, 6]. The most promising formulation that resulted from the two studies contained two synthetic materials: Cosmoloid H80 microcrystalline wax (as the replacement for beeswax) and Regalrez® 1126 hydrogenated hydrocarbon resin.

Extensive research on the workability and stability of a range of formulations containing these ingredients was conducted by the authors of this paper and is briefly summarised in the following section. Detailed information on this research is reported elsewhere [7, 8].

1.3. Summarised research on the stability and workability of the new PWR formulation

The main goal of the research was to find a new PWR formulation (referred to as NOVA-PWR) with working properties similar to that of Gamblin's Pigmented Wax/Resin Sticks, but that would not contain beeswax. The new formulation should be stable to different environmental conditions and be compatible with a

range of varnishes and inpainting media. The research work was, therefore, divided into three main parts:

The first part focused on understanding how the materials (Cosmoloid H80, Regalrez® 1126, fillers and/or pigments), and their presence in different proportions, influenced not only the physical and optical properties of the formulations, but also their behaviour in terms of preparation and application. The most promising wax:resin and wax:resin:filler/pigment ratios were identified and studied further.

The second part entailed an evaluation of the stability of the selected NOVA-PWR formulations to fluctuating temperature (T) and fluctuating relative humidity (RH) – thought to be responsible for the development of bloom [3] – in an environmental chamber. The PWR formulations were also exposed to high temperatures in the environmental chamber (50 and 60°C) and to radiant heat (up to 70°C), to monitor any changes due to softening of the material. Results were assessed with macro photography, digital microscopy, hardness measurements and Attenuated Total Reflectance-Fourier Transform Infrared Spectroscopy (ATR-FTIR), and compared to those obtained for Gamblin's Pigmented Wax/Resin when subjected to the same environmental conditions.

Since PWR infills may require varnishing, adjustment with glazes or inpainting, the third part of the research consisted of testing a range of popular varnishes and inpainting materials for their compatibility with the NOVA-PWR infills.

This study showed that the best wax:resin ratio with Cosmoloid H80 and Regalrez® 1126 is 1.5 parts by weight of wax to 1 part by weight of resin. This ratio performed well across a wide range of RH and T.

Also demonstrated was that the amount of filler and pigment added can be significantly adjusted to meet the desired visual properties (e.g., in terms of opacity) and physical properties (such as hardness and flexibility) of the infill. The amount of inert filler and/or pigment could be successfully varied from 1.25 grams to 10 grams when added to 10 grams of the WR binder.

In terms of stability to high T, NOVA-PWR in the wax:resin ratio of 1.5:1 (parts by weight) was able to withstand T up to 70°C without losing carved texture or three-dimensional surface features (e.g., recreations of brushstrokes). However, samples with 2 parts of wax or higher (to 1 part of resin, by weight) were not stable to the high T (60 - 70°C) tested and developed blisters.

Results showed that the NOVA-PWR formulations do not develop bloom when subjected to fluctuations in RH and/or T. However, due to the presence of beeswax in

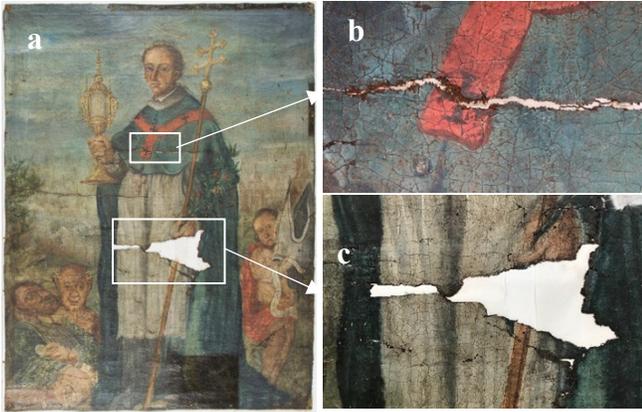


Figure 1 – a) Saint Norbert of Xanten before the application of the PWR infills; b) detail of one of the horizontal tears; c) detail of the large losses

their composition, the Gamblin Pigmented Wax/Resin formulations did develop bloom when subjected to the same environmental conditions.

Cracking was observed both in the NOVA-PWR and Gamblin formulations when applied to already severely cracked paintings with model paint made with a natural resin binder. The infills were applied to these paintings then subjected to fluctuations in RH and Tⁱ.

On a molecular level, no visible differences in the ATR-FTIR spectra of the NOVA-PWR samples were detected before and after the environmental trials.

NOVA-PWR were found to be compatible with Paraloid B-72 isolation varnishes applied with 1-methoxy-2-propanolⁱⁱ, and with widely available inpainting media, such as Gamblin Conservation Colors (in Laropal[®] A81).

2. TESTING THE WORKABILITY OF THE NEW PWR FORMULATION ON TWO CASE STUDIES

To complement the research, it was considered crucial to test the workability and suitability of the NOVA-PWR in actual case studies.

Two deaccessioned canvas paintings from the Stichting Restauratie Atelier Limburg (SRAL), based in Maastricht, The Netherlands, were selected for this purpose. Although very different both in their materials and their age, as well as the subject depicted and the pathologies present, both paintings had a common problem that made them ideal candidates for testing PWR infills: each presented paint and ground losses that needed to be infilled, textured, and retouched. The fact that they differed radically – one being a four-century-

old oil painting on a linen canvas and the other, executed only twenty years ago using acrylic paint on a commercially prepared cotton canvas – proved very useful for testing the versatility of the NOVA-PWR infill formulations.

In addition, the type and size of the losses present made it possible to test different application techniques and to prove the suitability of the formulation when used solely as an infill that works as a base for retouching, and as a material that achieves the infill and reintegration of a loss in one single step.

2.1. Case study 1: *Saint Norbert of Xanten*, ca. 17th century

The first case study consisted of an oil painting on linen canvas (99 x 78.5 cm), likely dating from the 17th century or slightly later (fig. 1a).

The painting presented severe structural and aesthetic problems associated with physical damage, water damage and exposure to high humidity. The most significant damage was a large triangular-shaped loss (17 cm long, up to 10 cm wide) in the centre of the canvas and a rectangular-shaped loss adjacent to it (7.3 cm long, 1.4 cm wide) (fig. 1c). Two horizontal tears (31 cm and 21.5 cm long) were also present (fig. 1b), as well as several smaller tears mostly associated with the



Figure 2 – a) *Untitled*, before the application of the PWR infills; detail of the gap before (b) and after (c) filling with an Arbocel[®] BC 200 mixture

triangular-shaped loss. The painting was mist-linedⁱⁱⁱ subsequent to applying PWR fills.

2.2. Case study 2: *Untitled, signed JOZ, 2002*

The second case study was an abstract acrylic painting on a commercially prepared cotton canvas, signed “JOZ ‘02”, previously used in lining trials at SRAL.

At one point the painting had been cut off its stretcher around the edges close to the tacking margin, then after some time had been reunited with the tacking margins by lining. The cut line presented a gap (~ 0.3 cm wide) that required filling and retouching (fig. 2a-c). The painting was mist-lined prior to reintegration.

Due to the depth of the gap a mixture of Arbocel[®] BC 200, with Portafill[®] A40 (aluminium hydroxide), Klucel[®] G 4% in water (4 grams in 100 ml) and Evacon R was used and applied to the height of the canvas.

3. MATERIALS AND METHODS

3.1 Materials used for the NOVA-PWR applied in the case studies

- Wax: Cosmoloid H80
- Resin: Regalrez[®] 1126
- Fillers: Champagne chalk (CaCO₃), Kaolin, Portafill[®] A40 (aluminium hydroxide)
- Dry pigments: Burnt Umber, Terra di Sienna, Yellow Ochre, Brown Ochre, Titanium white and Cobalt blue

3.1.1. Cosmoloid H80

Cosmoloid is a brand name for a series of microcrystalline wax formulations, supplied by companies such as Kremer Pigmente GmbH & Co. KG, Talas, C.T.S and Zeus, and manufactured by Astor (now The International Group, Inc.). Cosmoloid waxes have been used in conservation for several purposes, for example as substitutes to beeswax.

Cosmoloid H80 has been recommended by Velson Horie as being an inert material with a suitable degree of hardness [11]. It has also been considered highly stable against chemical degradation [12].

Table 1 – Properties of Cosmoloid H80

	Melting point	Acid value	Density at 20°C
Cosmoloid H80	83-94°C [13]	0 [14]	0.85-1.05 g/cm ³ [14]

3.1.2. Regalrez[®] 1126

Regalrez[®] 1126 is a synthetic low molecular weight hydrogenated hydrocarbon resin that, along with Regalrez[®] 1094, has been widely used in conservation. Even though Regalrez[®] 1094 is more commonly used, especially as a picture varnish [15], Regalrez[®] 1126 was chosen for its higher molecular weight, higher glass transition temperature (T_g) and higher softening point (Table 2). For infilling, its higher softening point would provide more stability to T, such that impasto or a texture reproduction would be more likely to maintain their shape and sharpness when exposed to higher T. The higher T_g of Regalrez[®] 1126 also means that the resin is less “tacky” at room T, being less likely to attract dirt. Even if a higher T_g could lead to a more brittle material, the combination with wax (in PWR formulations) was expected overcome this problem. Regalrez[®] resins have been reported to be photochemical stable [15], UV stable [16] and resistant to accelerated environmental conditions [17]. They have high compatibility with waxes, making them easily mixed with beeswax or microcrystalline waxes [18].

Table 2 – Properties of Regalrez[®] 1126

	Molecular weight	T _g	Softening point	Density at 21°C
Regalrez[®] 1126	1250 g/mol [19]	67°C [19]	124°C [19]	0.97 g/cm ³ [19]

3.2. Preparation of the NOVA-PWR

The steps for preparing the NOVA-PWR “wafers” used in the case studies were as follows:

- 1) Weighing 6 grams of Cosmoloid H80 and placing it in a glass beaker.
- 2) Melting the wax by placing the glass beaker on a hot plate. The T required to melt the wax was approximately 70-75°C.
- 3) Weighing 4 grams of Regalrez[®] 1126 and grinding it in a mortar with a pestle to achieve a very fine powder. This proved to be a crucial step that greatly helped in mixing the resin with the wax, accelerating both the melting and the mixing process.
- 4) Pouring the powdered resin, little by little, into the glass beaker after the wax was completely molten. To facilitate the melting of the resin, which has a higher melting point than that of the wax, the T was increased to 85-90°C. To facilitate the mixing of both

components, a magnetic stirrer was used in the beaker at this stage.

5) After 20-25 minutes, the wax and resin were completely dissolved together. At this point:

- a) For case study 1: the fillers were added while heating and stirring. The amount of filler added depended on the opacity and hardness desired for the infill, and on the filler itself.
 - i) To make either chalk or kaolin infills, 10 grams of either filler were weighed and filtered through a fine mesh strainer before being slowly poured into the WR mixture. This was done to ensure that no large solid aggregates would be added to the mixture;
 - ii) To make infills with aluminium hydroxide, 15 grams of Portafill® A40 were weighed and gradually poured in the WR mixture. It was not necessary to use the strainer for the Portafill® A40, since this material did not form aggregates.

After the fillers were completely dispersed in the WR binder, the mixture was poured onto a silicone baking tray (see suppliers) in portions, forming small thin disks (wafers), to be later remelted if needed.

- b) For case study 2: the WR mixture was poured directly onto the silicone baking tray to be later remelted and mixed with pigments prior to use.

3.3. Different application methods employed in the case studies

3.3.1. Application on a canvas insert (Case study 1)

Due to the large loss in the support for case study 1, a fabric insert was required to restore the physical stability of the painting. PWR infills were to be applied on the canvas insert. A previously sized (with sturgeon glue) linen canvas with a density close to that of the original canvas was selected. Cosmoloid H80 and Regalrez® 1126 combined in different ratios were mixed with different ratios of three fillers: chalk, kaolin and aluminium hydroxide (Portafill® A40) (see suppliers). The mixtures were tested for flexibility and pliability during the research [7]. Those with the best results contained chalk in a ratio of 50% of WR binder to 50% of filler (by weight). The ratio of wax:resin chosen for the insert was 1.75:1 (parts by weight). A

higher amount of wax was chosen because of the large dimension of the insert and the concern that over such an expanse over a flexible support the relatively thin layer of PWR could crack. The same procedure was followed for the smaller loss adjacent to the large loss.

A heat press was used to achieve a uniform layer of the wax-resin-chalk mixture on the canvas inserts for both losses (fig. 3a, see suppliers). The thickness of the original painting (canvas + ground and paint layers) was measured using a calliper. The insert canvas had a similar thickness to the original. To match in overall thickness, the filling material needed to be, therefore, slightly thinner than the original ground and paint layers, to anticipate the added thickness from subsequent inpainting. To attain the desired thickness of the infill, thin metal plates were stacked on top of each other next to the inserts to allow for the thickness of the wax-resin-chalk mixture.

Thin disks of the infill material were laid out on the sized canvas with a sheet of baking paper on top. The heat press was set to a T of, approximately, 80°C, and pressure was applied by turning the wheel on top until the press reached the height of the metal plates. The result for both inserts was a uniform layer of infilling material, with a thickness of 0.8 mm.

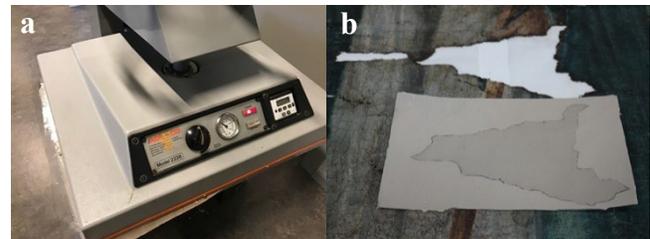


Figure 3 – a) Heat press; b) Piece of canvas for the insert after the application of the PWR in the heat press (below the loss with a Melinex® cut-out on top)

3.3.2. Imprinting texture with a silicone mould (Case study 1)

The next step was to apply texture to the surfaces of the infill material on the canvas inserts. Texturing the fills is a crucial part in loss reintegration for it will – if properly and accurately done – allow the reintegration to blend in with the original, becoming almost invisible to the eye of the viewer.

For this important step, and as recommended by authors such as Folkes and Reddington [20], the decision was to use a silicone mould to create a very accurate replication of the existing texture from a chosen area of the painting. As recommended by the authors, the

painting had already been cleaned but the intermediate coat of varnish prior to retouching had not yet been applied. The area of the paint surface selected for the texture was not adjacent to the losses but below them and included the same colours – therefore, the same cracking pattern – as would have been in the area that was lost. Before making the silicone mould, a thin coat of Regalrez® 1094 10% varnish (80 grams of resin in 200 ml of white spirit, 400 ml of iso-octane and 200 ml of Shellsol® D40) was brushed over the selected area of the painting to protect it from “direct contact with the silicone” [20]. The silicone mould – Silicone C 20 by Silicones and More – was prepared according to the instructions given by the manufacturer. The silicone solution was then brushed over the painting, creating a layer of approximately 0.2 cm. A sheet of 100µ thick Melinex® was placed on top for it “facilitates the mould’s removal from the painting and provides a resistant-free surface during the process of ironing” [20]. The silicone mould was left to cure for approximately 24 hours, after which it was removed from the painting with the help of a spatula and a small cylinder. The cylinder was used to roll the mould and the Melinex® sheet, which proved to be very helpful when detaching them from the painting (fig. 4a). The layer of Regalrez® 1094 varnish applied to the paint surface was then removed with isooctane.

To imprint the paint texture onto the inserts, the silicone mould was placed over top of them. Care was taken to avoid imperfections in the mould when positioning it over the inserts.

A heat spatula (see suppliers) set to a T of approximately 90°C, was then used to iron over the surface of the mould (fig. 4b). The top surface of the filling became somewhat molten, accepting the texture from the mould. Folkes and Reddington [20] warn not to use Ts that are too high since that would “leave a slightly wavy and uneven surface as the wax begins to flow.” The texture was transferred to the inserts before they were cut to their final shape, because this meant that it would be possible to choose which part of the imprinted texture to include. To cut the inserts to correspond to the shape of the losses, outlines of the losses were first drawn on Melinex® sheets using a permanent marker, then the Melinex® sheet was cut out and placed over the filling material. Using a scalpel, the filling material was cut out along the outline. To aid the cutting process, a soft, malleable surface was placed under the insert, in this case, a thin lead plate (fig. 5).



Figure 4 – a) Using a roll to detach the silicone mould; b) heat spatula ironing the surface of the mould



Figure 5 – Insert after having been cut with a scalpel on top of a thin lead plate

The attachment of the edges of the inserts within the losses in the painting was done from the reverse with BEVA® 371 film. To ensure that the inserts would remain in place until the painting was lined, an interleaf of Parafil RT 20, a non-woven polyester fabric, covered with Plectol® D360 was attached to the reverse of the inserts. Although the application of the interleaf involved heat, the wax-resin-chalk infill layer did not show any changes in texture.

Once the inserts were successfully secured, the painting was turned face-up to allow for smoothing and flattening of the edges of the inserts. This step was done using a metal dental spatula (see suppliers) which was regularly heated on a small hot plate (in this case, a coffee-mug warmer was used - see suppliers) to soften the filling material locally (fig. 6). Small amounts of the wax-resin-chalk filler were melted directly into any gaps between the insert and the painting using a wax carving pencil (see suppliers). Raking light from different angles and directions was used during the entire process to ensure a seamless join between the inserts and the painting.



Figure 6 – Smoothing the edges of the insert and filling small gaps between the canvas and the insert

3.3.3. Infilling losses (Case study 1)

In addition to the large losses, other smaller losses, mainly associated with horizontal tears, required filling. For these fills, three NOVA-PWR mixtures containing chalk, kaolin, and aluminium hydroxide (Portafill® A40) were evaluated for their workability, ability to receive texture and visual appearance.

The application process was similar for all mixtures:

1. The wax-resin-filler mixtures were prepared according to the procedure described in Section 3.2 resulting in solid wafers;

2. Wax-resin-filler wafers were softened or melted with heat and applied to the tear area. This was done in two different ways:

- a. A small amount of solid wax-resin-filler wafer was placed on a sheet of aluminium on top of the small hot plate set to a T of approximately 70°C. When it was only slightly molten and therefore paste-like, the dental spatula (which had been warmed on the same hot plate) was used to transfer the mixture to the tear area. Since the working time of the mixture was short, this was done quickly and repeatedly;
- b. A thin film of the solid wax-resin-filler mixture was placed directly into the loss and melted, little by little, with the tip of the wax-carving pencil (fig. 7).

3. After it had solidified in the loss, the wax-resin-filler mixture was smoothed and levelled. Smoothing was carried out in different ways:

- a. By using a metal spatula warmed on the hot plate to lightly pass over the surface; or
- b. By the application of a small amount of white spirit. The solvent could be delivered using a small cotton swab which was gently rubbed over the surface; or by using a smoothed wine cork (cut at an

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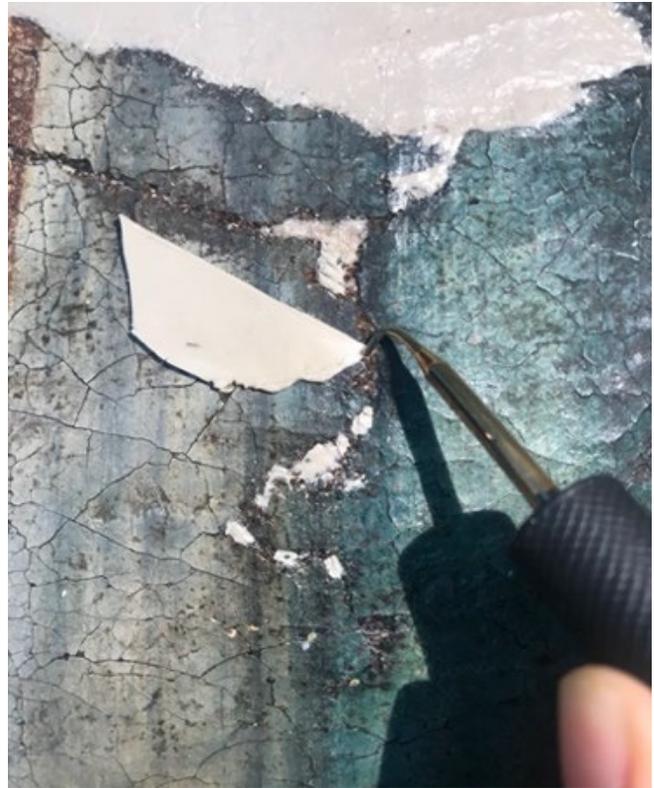


Figure 7 – PWR fill being melted directly on the loss with a wax-carving pencil (see suppliers)

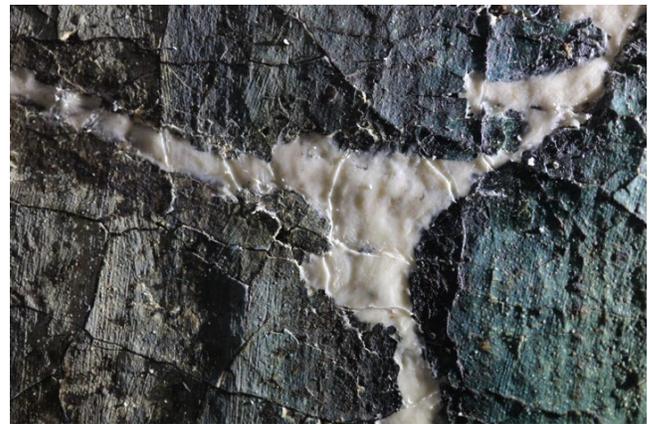


Figure 8 – Replication of the surrounding texture on the PWR fill done by carving with a scalpel

angle and sanded). The smoothed cork surface was dipped in white spirit and “rotated in a circular motion to remove surplus filler” [20].

4. Generally very little residue was left on the original paint using these methods, however where it did occur the paint surface was cleaned with a fresh cotton swab dipped in white spirit. All residue was

easily removed without damaging the paint underneath and the infill in the tear was smoothed at the same time.

5. After smoothing and levelling the infill, the paint surface surrounding the loss was replicated using the silicone mould or simply by carving into the infill with a scalpel. For small infills, a scalpel was used to carve a continuation of crack lines, connecting the existing ones from the area above and below the tear (fig. 8). The use of raking light from different angles was very important while replicating texture, as it greatly enhanced the existing texture on the painting and the progress in achieving a match in the infill.

3.3.4. Infilling and colour integration (Case study 2)

One of the greatest advantages of PWR infills is that colour matching can be made directly by introducing the appropriate pigments to the WR mixture. Case study 2 was a good candidate for this method. The colour of the infill can be easily adjusted during pigment introduction. Figure 9 illustrates this method. To ensure an accurate match, colour options were applied on a commercially prepared canvas and placed near the gap for a visual evaluation (fig. 9a). Alternatively, solid samples of PWR mixture could have been placed directly on the surface of the original paint to evaluate what colour adjustments are needed.

Another option for colour matching, is to have PWR wafers ready-made in a range of, more or less, pure pigments. Individual wafers can be melted on the hot plate in greater or lesser amounts (as one does when mixing paints) to effect a colour match with the original paint. Both methods can be used, with powdered pigments introduced into the molten WR mixture, followed by melting pure colour from a pre-made wafer(s) beside it on the aluminium then mixing both together to adjust the colour.

For case study 2, the reintegration of the losses was done in several steps:

1. A wafer of the WR mixture was melted on a piece of thick aluminium (see suppliers) with the hot plate set to a T of approximately 75°C (fig. 9b). The T could be increased as necessary and was used in a range between 75 and 85°C.

2. Powdered pigments were introduced while the WR mixture was in a molten state on the hot plate (fig. 9c). In some cases, more than one pigment was added to achieve a match with the original paint surrounding the loss.



Figure 9 – a) Colour matching evaluation of fills with different pigments; b) WR mixture being melted on a small hot plate (coffee mug warmer); c) pigments added to the WR mixture while on the hot plate

3. The resulting PWR mixture was introduced into the loss using the dental spatula heated on the hot plate. To build thick impasto, the PWR was applied in layers, allowing the mixture below to solidify (it hardened quickly in approximately 7 seconds). It proved very easy to build the desired infill thickness (fig. 10). The dental spatula could also be heated using a hot air gun, and the wax carving pencil proved useful as well. In the case of the wax carving pencil, a T set to 75-78°C was suitable for melting the PWR fill. When set to between 55 and 60°C the PWR only softens which allows it to be shaped and sculpted in situ.



Figure 10 – Recreation of an area of impasto

4. For case study 2, the surface of the PWR needed to be somewhat matte. After application and texturing (which left a glossy surface), a piece of matte baking paper was placed over the infill, and light pressure applied with the dental spatula to achieve a matte surface. It was not necessary to apply a final coating layer to the PWR, as experimental results confirmed that the WR materials employed would not bloom in the future, and the surface T_g was unlikely to attract any more dust than the paint surface.

4. RESULTS AND DISCUSSION

4.1. Case study 1

In terms of the application of the NOVA-PWR over the significant surface area presented by the canvas insert (approximately 17 cm long and up to 10 cm wide) the results were very satisfactory. The biggest challenge consisted of finding a way to apply a homogeneous layer of infill with a specific thickness, given that the material is only workable when warm. This was successfully accomplished by using a commercial heat press which provided uniform heat and pressure.



Figure 11 – Insert in raking light after Mist-Lining

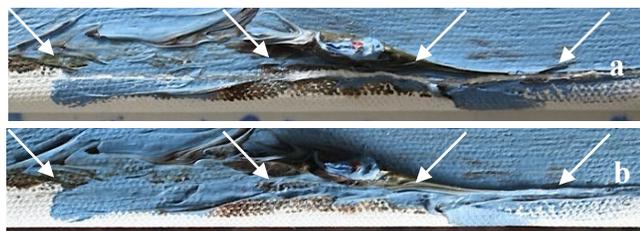


Figure 12 – Gap area before (a) and after (b) being filled with NOVA-PWR

The NOVA-PWR formulation with chalk could be easily imprinted with texture transferred from a silicone mould. Furthermore, no changes in the infill texture

were observed after the painting was mist-lined (fig. 11).

Local applications of the NOVA-PWR in the horizontal tears were straightforward, with different application methods possible. In terms of the fillers tested, chalk, kaolin, and aluminium hydroxide (Portafill® A40), all gave easily workable formulations. The main difference was the colour of the final infill: chalk gave a light beige tone, kaolin a darker-yellowish tone, and aluminium hydroxide was the whitest.

The next step of the treatment would have been to inpaint on top of the PWR infills to achieve colour integration. Results for the compatibility of NOVA-PWR with varnishes and inpainting media showed that the following combinations could be successfully used [7]: Paraloid B-72 10 or 5% in 1-methoxy-2-propanol (as an isolation layer) followed by inpainting with Gamblin Conservation Colors (in Laropal® A81), with a top layer of Paraloid B-72 varnish^{iv}.

4.2. Case study 2

The second case study was especially useful for validating the advantage of the NOVA-PWR for infilling and reintegrating a loss in one single step, by adding pigments (or mixtures of pigments) to the WR binder. Because the colour of PWR infills does not change when passing from a fluid to a solid state, an accurate match to the uniform paint colour surrounding the losses could be made easily.

Colour matching was also facilitated since the solidified PWR could be placed directly on the paint surface for comparison.

5. CONCLUSIONS

NOVA-PWR infills composed of Cosmoloid H80 microcrystalline wax and Regalrez® 1126 (hydrogenated hydrocarbon resin) in a ratio of 1.5 to 1 parts by weight of wax to resin, in combination with fillers and/or pigments proved to be good alternatives to PWR infill formulations containing beeswax.

Extensive testing demonstrated that the NOVA-PWR formulation is stable in fluctuating RH and T, as well as to radiant heat. Case study 1 showed that the formulation is stable during Mist-lining.

NOVA-PWRs also proved to be highly versatile as they could be applied onto large canvas inserts, prior and post lining, as well as directly into small losses.

Although effective and suitable, PWRs can be challenging to apply on large losses, as the material hardens rather quickly (~7 seconds). This means that, in order to achieve a large homogeneous layer of PWR, it may be necessary to resort to additional equipment, such as the hot press described above, that will maintain the PWR warm and soft and will create a homogeneous layer of the material, for example on top of an insert canvas.

Colour matching was easily achieved by mixing different pigments to the WR mixture, particularly because the hue remains unchangeable throughout the entire process. Although most advantageous in situations where a quick colour match is done, PWRs also proved useful materials for infilling losses that will receive inpainting on top. This is especially true due to the ability of the material to easily receive texture, both by carving with a scalpel or imprinting with a silicone mould, and be sculpted.

The possibility of manipulating the final gloss of the PWRs was also verified. This is an indication that, in some applications, colour-matched NOVA-PWRs may not require further treatment with varnishes. Even if compatible with popular varnish and inpainting materials, since NOVA-PWRs are not prone to bloom or attract dust, it is not considered necessary to apply a protective coating over them.

Pre-prepared NOVA-PWRs, in the form of thin wafers or sticks, can be stored indefinitely and reactivated for use at any time. A selection of ready-made colours (which can be mixed together when molten) can be on hand for achieving colour mixtures for immediate infilling and colour matching.

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ⁱ This requires further research with more realistic samples of aged and cracked oil paintings on canvas. Note that traditional chalk/glue infills were not tested in the same conditions for comparison.

ⁱⁱ 1-methoxy-2-propanol was tested solely as a component of an isolation varnish applied on top of the PWR fills. It should not be used as dilutant in varnishes applied on oil paintings [9].

ⁱⁱⁱ Mist-Lining is a cold, low-pressure lining technique developed at SRAL [10].

^{iv} Because of its medium-high swelling effect on oil paint it is recommended that if a Paraloid B-72 varnish is to be applied over the entire surface of the original painting, the 1-methoxy-2-propanol solvent should be replaced with Shellsol A100 or other equivalent slow evaporating fully aromatic hydrocarbon solvents. The practitioner should wear appropriate PPE when applying such varnishes. Testing on the painted surface is always required prior to any varnish application.

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MATERIALS AND SUPPLIERS

Equipment:

- Gas Stove Burner Covers, Disposable Aluminum Square Foil [https://www.amazon.com/Aluminum-Square-Stove-Burner-Covers/dp/B07GFQLS3J]
- Coffee mug warmer, model CO294-CW, Cosori [www.cosori.com]
- Digital precision balance standard, Ohaus
- Hot plate with magnetic stirrer, model 34532, Snijders [www.geminibv.com/labware/snijders-hotplate-34532-stirrer/]
- Hydraulic Dry Mounting and Laminating Heat Press on Stand, Model 2226, Ademco
- Dental Modeling spatula, Model: Ceramic, Restaurar&Conservar [www.restaurarconservar.com]
- Silicone baking tray, MOUL'FLEX [www.debuyer.com/en/493-moulfex]
- Tacking Spatula Iron Thermocontrolled, Restaurar & Conservar [www.restaurarconservar.com]
- Whipmix Wax CarvingPencil: Wax carving pencil, commercialised by Gamblin Conservation Colors

A new Pigmented Wax-Resin formulation for infilling and reintegrating losses in paintings: testing its workability in two case studies

Product	Supplier
Arbocel® BC 200	Kremer Pigmente GmbH & Co. KG
Champagne chalk	www.kremer-pigmente.de
Cosmoloid H80	The International Group, Inc. https://igiwax.com/
Evacon R	Conservation By Design, Ltd. https://www.cxdinternational.com/
Kaolin (#58250)	Kremer Pigmente GmbH & Co. KG www.kremer-pigmente.de
Melindex® 100µ	PEL Preservation Equipment www.preservationequipment.com/
Parafil RT 20	Deffner & Johann GmbH https://deffner-johann.de/en/
Burnt Umber, Terra di Sienna, Yellow Ochre	Kremer Pigmente GmbH & Co. KG www.kremer-pigmente.de
Titanium white, Cobalt blue, Brown ochre	H. Schmincke & Co. GmbH & Co. KG www.schmincke.de/en.html
Plextol® D360	C.T.S. www.ctseurope.com/gb/
Portafill® A40	Laboratory Jan de Poorter www.ankerpoort.com
Regalrez® 1094 and 1126	Kremer Pigmente GmbH & Co. KG www.kremer-pigmente.de
Shellsol® D40	
Saga Baking Paper	Sligro - www.sligro.nl
Silicone C 20	Silicones and More www.siliconesandmore.com