INFILL AND RETOUCHING APPROACH ON PAINTING ON COPPER SUPPORT, 1790 – 2022. MATERIALS AND TECHNIQUES

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Abstract

The scarcity of literature on the methods and materials used to restore copper paintings underscores the historical significance of this research. This article provides an overview of the infills and retouching materials applied to paintings on this metallic support from 1790 to 2022. The research identifies at least eight historical written sources produced before 1899 and fifty-five contemporary sources produced between 1900 and 2022. The range of products and procedures applied varies from traditional materials like carbonate calcium mixture with animal glue to synthetic resins, and from using brushes to carving heat pencils for application, respectively. Exploring the diverse practices over the last two centuries will not only help conservators make informed decisions on which materials and techniques to use during painting on copper restoration, but will also aid scientists in accurately interpreting the data collected from these objects during scientific analyses.

Keywords:

painting on copper,

infills,

retouching materials,

restoration, conservation

Introduction

Oil painting on copper plates probably started to be executed in Italy or Flandres in the 16th century (van de Graaf, 1976). Although its production declined to the end of the 17th century in European countries, it reached new flourishing markets worldwide, especially in the Viceroyalty of New Spain (Bargellini, 1999). Its small dimensions and high resistance (Vega et al. 2018) presumably made it an excellent means of transport for the taste and faith of the old world.

When comparing these types of paintings to the two principal forms of easel painting—those on canvas and wooden panels—certain similarities in their structural systems can be identified. From the back to the front, all of them have 1. the support, 2. the size layer, 3. the ground layer, 4. the paint layer, 5. the glazing (not always present), and 6. the varnish coating (**Fig. 1**).

Fig. 1 **Representation of the painting system of a painting on copper (a) and a painting on canvas (b)**

1. Support; 2. Size layer; 3. Ground layer; 4. Paint layer; 5 Glazing and 6. Varnish

Besides using non-hygroscopic support, the most evident difference within these easel paintings is the thickness of the whole system over the substrate and the ground layer composition. Paintings on metal are extremely thin. According to microscopic and μ-Raman spectroscopy analysis, the ground layer has an average thickness of 20 microns. It is mainly composed of a mixture of oil, lead white and earth pigments [3], while paintings on canvas and wooden support have an average thickness of 100 microns. The ground layer is composed of carbonate calcium or calcium sulphate with a hide glue (Valada et al., 2016). Another substantial difference, not directly connected with their materiality, is related to the conservation and restoration literature dedicated to each. Paintings on metallic support are the group with the scarcest detailed literature.

To date, systematic research has yet to be conducted to comprehend the evolution of conservation and treatment procedures for paintings on copper. However, due to the development of a database at the University of Fine Arts in Lisbon aimed at studying paintings on metallic supports, it has become possible to achieve this objective. This research underscores the urgent need for further exploration in this field, as it identifies a significant body of literature related to infills and retouching materials for paintings on copper.

Documentary research

The text provides an overview of the extensive research conducted on painting on metallic support. Various sources, including art treatises, artists' manuals, encyclopedias, scientific articles, and dissertations, have been compiled, totalling over 650 references from 1600 to 2022. Among these, 77 documents delve into topics related to conservation and restoration treatments (Fig 2). Spanish contributions to the study of painting on copper support stand out, with notable mentions of artists such as Carducho (Carducho, 1633) and Pacheco (Pacheco, 1649) detailing their experiences with paintings on copper in the 17th century. Moreover, Universitat Politècnica de València has been consistently producing academic works on this subject since 2017, likely driven by the organisation of the inaugural symposium "Paintings on copper and other metal plates: Production, degradation, and conservation issues" (López et al., 2017).

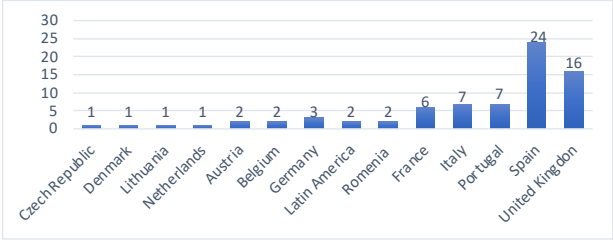

Fig. 2. **Distribution of the bibliography concerning Conservation and Restoration treatments**

These 77 documents give us a better understanding of the most common practices applied to paintings on copper

(Fig 3). 90% of the restoration treatments are executed on the chromatic layers. Of these percentages, 16% and 18% correspond to Infill and Retouching procedures, respectively. The literature available represents 55 sources.

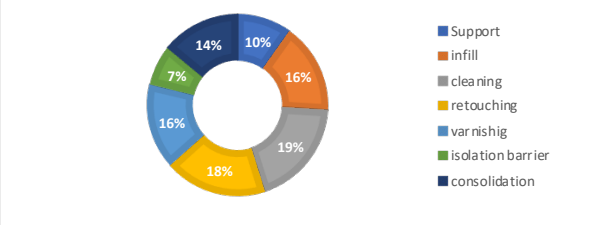

Fig. 3. Distribution of the leading conservation and restoration topics in the consulted bibliography

The losses

Loss in the context of oil painting refers to a disruption in the layer system. In the case of paintings on metallic support, losses are usually extensive, affecting all layers from the upper organic coatings to the inorganic substrate (Fig 4), regardless of whether the loss stems from mechanical, physical, or chemical causes. Poor handling, for instance, can lead to loss in the chromatic layer and its support, often evidenced by damage along the edges of metallic plates. Chemical decay processes are attributed to the metal's tendency to corrode, determined by factors such as purity, alloying, crystallographic structure, and surface characteristics. Exposure of the metal due to losses or cracks can lead to the migration of water and ions to the oil paint/copper interface, initiating electrochemical reactions and promoting adhesion loss (Fig 5). Lydia Pavlopoulou and David Watkinson note that destabilisation begins with bond failure, laying the groundwork for delamination (Fig 6) (Pavlopoulou & Watkinson, 2006). Furthermore, aqueous surface treatments and conservation procedures could hasten degradation (Fig 7).

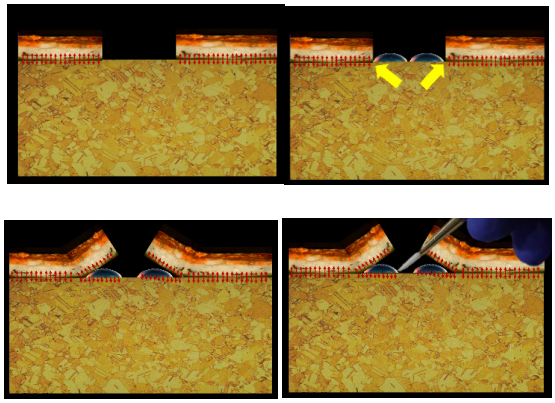

Fig. 4. (a) Representation of the typical loss present on painting on copper, (b) Representation of ingress of water to the oil paint/copper interface, (c) Representation of beginning of the failure bond within the system, and (d) Representation of surface treatment or conservation treatments that use moisture.

Written sources before 1899

Documentation consulted points that three traditional infills were possible to use for losses on painting on copper support (Table 1):

1. An inert, such as calcium sulphate or the pigment Spanish white, mixed with an animal glue. Vicente Polero mentioned that calcium sulphate could not be substituted for any other material since the infill property would be compromised (Polero, 1853). Filling the loss had four steps: 1. Place the infill over the loss, 2. Remove the excess material; 3. Clean the area, and 4. Texturing the infill to imitate the surrounding area. The same author advised the extreme necessity to work consciously and remove all possible dust after levelling the infill so as not to contaminate the retouching or the new varnish coat (Polero, 1853). Forni adds extra information. He suggested that the gypsum would not adhere correctly to the support by itself and, consequently, it would be impossible to level the surface, so fresh garlic should be crushed before applying the infill. Its juice is applied over the metallic surface of the loss by brush (Forni, 1866). For his part, De la Roca detailed better some of the steps that Polero mentioned: the infill must be taken in a small portion with the tip of the palette knife and placed on the palm of the left hand, then it was beaten again and collected towards the centre; it was taken with the knife the portion that is enough for filling the loss, taking care that it was placed in such a way that it would form a slight prominence, which was necessary for the scraping operation (Delgado, 1871). According to De La Roca, the step that Polero referred to as 'clean the area' involves using a fine sponge moistened with clear water, which is gently passed over the infill to dampen it, followed by scraping it with a standard sharp knife.
2. An oil putty. It was prepared by mixing a drying oil and a resin with pigments. Diderot mentioned the type of pigments/inert to add to the oil putty, umber and clay. Drying oil was not the same for preparing oil paints (linseed oil); it was walnut oil (Diderot & Alambert, 1791). Secco is the only author who has given us the ingredients and proportions to prepare the oil putty. On the other hand, Picault and Hampel disclosed exciting details about the practice of restoring painting on copper. Picault said that the

paint layers did not need to be consolidated; they just needed to be scrapped off till the sound paint layer before applying the putty. Although Hampel did not directly mention the word "oil putty", he said the "coloured infill" must be applied gradually by brush till the level of the surrounding area (Hampel, 1846).

3. Wax-resin. This infill is just mentioned by Deón (Deón, 1851); he also suggested the possibility of just applying virgin wax. According to the same author, adding ***sanguine*** was not just added to give some colour to the infill but also to make it harder.

Regarding the retouching approach in this literature, Picault wrote vaguely about how retouching was performed (Picault, 1793). He just recommended applying colour over the losses, not to mention the kind of binder used. Hampel, who probably was familiar with coloured oil putty, recorded that the "coloured infill" must be applied in the area of lack of paintings. Polero advised that the tint used in the retouching should be diluted more in oil than the original to achieve the transparency, delicacy, and tenuity of the other colours applied to the work. Forni and Secco (Secco, 1866) had a practice closer to modern ateliers; they suggested using watercolours in the first layers, followed by a thin layer of varnish to saturate the painting. After that, retouching colours must be prepared with Dammar resin to match perfectly the original. On the contrary, De la Roca suggested that the binder should be mastic resin.

Table 1. Written sources before 1899

		Infill			Retouching binder	Chapter/ pages
Year	Author	Inert + hide glue	Oil putty	Wax-resin		
1791	Diderot	-	Walnut oil + umber + clay	-	-	24
1793	Picault	-	Yes	-	oil?	XXXIII
1846	Hampel	-	Yes?	-	oil?	51-2
1851	Deón	Spanish white	-	+ red blood-	-	20-1
1853	Vicente Polero	Gypsum	-	-	oil-	
1866	Forni.	Gypsum	-	-	Sheepskin glue, honey, gum Arabic?, Dammar resin	77, 151-2
1871	De la Roca y Delgado	Gypsum	-	-	Mastic resin-	98-101 102-105
1886	Secco	-	Walnut oil: turpentine (1:4) Walnut oil: mastic resin (1:3)	-	Sheepskin glue, honey, gum Arabic?, Dammar resin	XILX LXV

Written sources after 1900

After 1900, a wide variety of products appeared in the common practice of restoring paintings on copper. Nevertheless, infills are not the primary concern among easel painting conservators since just 22% are concerned with this issue; in comparison, 78% are more attentive to the chromatic reintegration phase (Fig 8). This situation could be explained by the fact that the paint layer is extremely thin, and as we will see ahead, the retouching itself could be considered the filler itself.

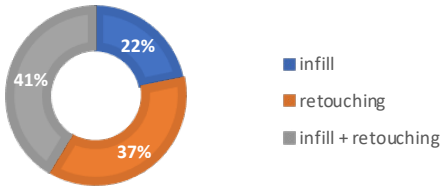

Fig 8. Distribution of the bibliography concerning Conservation and Restoration treatments

The infill materials can be classified as traditional, similar to older practices, and modern, which includes ready-made products, or a mixture of pure reagents bought in the shops and prepared at the studio. Simultaneously, all materials can be divided into aqueous and non-aqueous infills (Table 2).

Although aqueous products should be avoided since they could promote corrosion or retain moisture from the environment, some authors suggest the use of an isolating layer of synthetic resin that would act as a water barrier prior the application of an aqueous infill (Instituto del Patrimonio Cultural de España [IPCE], 1996; ICPE, 1998; Maule, 1999; Broers, 2002; ICPE, 2004; Campo et al., 2009; Cox et al., 2016; Vega et al., 2017; Albaladejo et al., 2017; Petcu, 2017; Rubio, 2019; Vergeer, 2019; Armero, 2020; Mora, 2021; De la Torre, 2021; Rodrigueza et al., 2022). The material most often used for the isolation is the copolymer of ethyl methacrylate and methyl methacrylate, most known as *Paraloid*-B72.

Paraloid B-72 is one of the few polymers with an estimated duration of 100 years. It can also be stored without changes in its transparency for more than 200 years (according to accelerated ageing studies) (Feller & Curran, 1975). It is a stable resin. Nevertheless, compared with other resin acrylics, its high-water permeability decreases its useful life (Kovács et al., 2021).

The aqueous ready-made products listed (Modostuc, Fine Surface Polyfilla, Lascaux 500, Liquitex, and Daler Rowney Texture Paste) are commercial products with complex formulations described in their manufacturer's datasheets. As a result, the uncertainty surrounding their ingredients and the inability to ensure that the manufacturer will use the same formulations beyond the initial purchase means that these commercial materials cannot be relied upon regarding their longevity or repeatability.

The non-aqueous ready-made product listed is Gamblin Wax-resin. Although the material is a good option as an infill, it contains beeswax, which promotes metal corrosion (Vega, 2017; Vega et al., 2017; Vega et al., 2018).

In most cases, the application methods are carried out by brush, which is relatively straightforward. The primary concern with ready-made products is their aqueous nature and the potential presence of unknown ingredients. Non-aqueous infill mixtures are typically composed of a synthetic polymer, a solvent, a filler, and pigments. However, none of these materials are suitable as infills for paintings on metal supports, except for acid-free pigmented wax resins (refer to Table 3).

Finally, according to some authors, Paraloid® B72 resins could be used in a reduced percentage of 5-10% with the addition of a pigment and applied in multi-layers to build up the level of the loss with the surrounding area (Bjarnhof, 1987; Arestiño & Guimil, 2006; Mugniot, 2007; ICPE, 2007).

Table 2. Written sources after 1900

		Infill				Retouching			
Year	Author	Traditional	Ready-made	Mixture	Not specified	Traditional	Ready-made	Mixture	Not specified
1981	Schneider	-	-	-	-	-	-	-	X
1983	Réunion des musées nationax	-	-	-	-	-	-	-	X
1983	Leegenhoek-Wade	1,2	-	-	-	-	-	-	-
1987	Bjarnhof	-	-	-	-	-	-	PBp	-
1990	Alvarez	-	-	4	-	-	-	4	-
1990	Guinea J.	-	5	-	-	-	M	-	-
1992	Garrell	2	-	-	-	-	-	4	-
1993	Moncrieff	-	F	-	-	-	-	PBp	-
1994	IPCE BM 116-42	-	-	-	-	-	-	R	X
1995	Berger	-	-	6	-	-	-	6	-
1996	Horovitz	-	L,R	7	-	-	-	-	-
1996	IPCE NM 97-35	-	-	-	-	-	-	-	X
1996	IPCE BM 117-5	-	-	-	-	-	-	4	-
1998	IPCE BM 97-27	-	-	-	-	-	-	4	-
1999	Moule	1	-	-	-	Egg	-	MS	-
2002	Broers	-	H	-	-	-	-	-	-
2002	Horovitz	-	L,a	-	-	-	-	-	-
2003	Vivancos	2	-	P67p	-	-	-	-	-
2004	Koltz	1	-	-	-	w	G	-	-
2004	Orietta	3	-	-	-	-	-	4	-
2004	IPCE BM 460-8	-	A	-	-	w	-	-	-
2006	Terenzi	-	R	t,ac	-	-		4, 7	
2006	Arestiño	-	-	-	-	-	-	PBp	-
2007	Mugniot	-	-	-	-	-	-	PBp	-
2007	IPCE BM 275-2	-	-	-	-	d	M	PBp	
2008	Rizzo	-	Md,Gr	-	-	-	-	4	-
2008	Bergerovi	2	-	-	-	or	-	-	-
2009	IPCE BM 514-5	-	-	-	-	-	-	-	X
2009	Campo	-	-	-	-	-	-	4	-
2016	Coxs	-	-	PB72	-	-	-	4	-
2017	Vega	-	GWR	2		-	-	-	-
2017	Vázquez	-	-	-	-	-	M	-	-
2017	Kasiulvte	-	-	Px	-	-	-	op +Px	-
2017	Petcu	1	-	-	-	-	-	PBp	-
2017	Magdaleno	-	-	-	-	-	-	-	X
2017	Horovitz	-	L,a	-	-	-	-	-	-
2017	Vega	-	-	2	-	-	G	-	-
2018	Gonzalez	-	-	2	-	-	-	-	-
2018	Lalli	-	-	3+3	-	-	-	LP	-
2019	Aranda	-	-	-	-	-	-	4	-
2019	Vergeer	-	-	2	-	-	G	-	-
2020	Armero	-	-	PB72	-	-	-	-	-
2020	Sonoc	-	-	Bg	-	-	M	4	-
2021	Mora	-	-	PB72	-	-	G	-	-
2021	Sánchez	-	-	-	-	-	-	-	X
2022	Rocher	-	-	-	-	-	-	4	-

Regarding the retouching materials, conservators prefer to use synthetic materials, namely PB72 or retouching varnish mixture with pigments.

Commercial brands such as Gamblin Conservation Color or Maimeri retouching colours are also preferred. Hamilton Kerr Institute has a long tradition of using egg tempera as a

References: 1- chalk/ Gesso + hide glue; 2 – Wax-resin; 3 – Wax; 4- Varnish + pigments; 5- Varnish; 6 – *Paraloid* B72 + Chalk; 7- PVA + pigments; 7- resin + pigments; a- acrylic infill; ac – Acylic colours; A- Acrylic Texture Paste; Bg- Beva Gel 37 + chalk; d – dammar + pigments; F- Fine Surface Polyfilla; G- Gamblin Colours; Gr- Gel Relief Lefranc & BOUGEON; GWR – Gamblin wax-resin; H- Hydrogrund Lascaux 500; L – Liquitex M- Maimeri colours; LP– Laropal + pigments; Md – Modostuc; op- Oil paint; or- Oil resin + pigments; PB72- *Paraloid* B72; PBp-*Paraloid* B72 + Pigments; MS- MSA2 + pigments; P67p – *Paraloid* B67 + Pigments; Px- Plextisol P550-40 + pigments; R- Darler Rowney Texture Paste; t- tempera; w – water colours //blue: aqueous materials orange: non-aqueous materials

retouching material. Conservators who use egg tempera say that this product is a healthy option and that once it has dried, it is less hygroscopic than either gouache or watercolour (Kempsky, 2010).

Table 3. Application methods and observation of the ready-made infill behaviour

Type	Product	Application method	Observations
Ready-made	Polyfilla	Brush	Pro: ease of application, spread well Cons: unknown components on the formulation, white ghosting, and water required for cleaning and texturing.
Ready-made	Modostuc		
Ready-made	Liquitex	brush	Pro: ease of application, spread well, useful for significant losses Cons: unknown components on the formulation, rubbery texture, difficult to carve once dried.
Ready-made	Acrylic texture medium	brush	Pro: ease of application, spread well Cons: unknown components on the formulation, rubbery texture, difficult to carve once it dries.
Ready-made	Hydroground Lascaux 750	brush	Pro: ease of application, spread well, hydrophobic when dries (?) Cons: Unknown components of the formulation swell when relative humidity increases.
Ready-made	Gamblin wax-resin	Warm spatula, Wooden skewer	Pro: Naturally hydrophobic, colour reintegration match possible Cons: acidity of the beeswax used
Mixture	Paraloid B72 (20%)	brush	Cons: difficult to apply; it could act over the isolation varnish
Mixture	Paraloid B48 (20%)	brush	Cons: difficult to apply, it could act over the isolation vanish
Mixture	Plextol B500-40	brush	Cons: adhesion to the support is altered when the filler is added
Mixture	Beva 371	brush	Cons: no adhesion to the metallic surface
Mixture	Pigmented wax-resin	Warm spatula, wooden sticker	Pro: control over the progression of the infill, colour matching possible, acidity problem controlled, double isolation system over the losses. Cons: time-consuming when compared with other solutions.

Conclusions

In the realm of painting on copper, the selection of appropriate infill or retouching materials requires a comprehensive exploration. The evolution of past practices and materials has rendered this task increasingly complex, as each object presents unique requirements that demand careful consideration in aligning with a suitable polymer. With many options available today, professionals are tasked with meticulously evaluating the features that render a specific product ideal for the painting. Parameters to contemplate include application, rheology, reversibility, ageing characteristics, and solubility in particular solvents. An investigation revealed 63 written sources offering insights into infill and retouching materials, indicating a notable shift from traditional to synthetic materials during the latter decades of the 20th century. Presently, conservators' prevalent application of non-aqueous infills is indicative of this transition, coupled with a discernible inclination toward employing ready-made materials. Notably, products formulated with *Paraloid* B-72 and microcrystalline wax emerge as particularly promising among the listed options.

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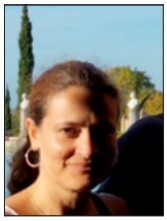

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