LE FASI FINALI NEL RESTAURO DELLE OPERE POLICROME MOBILI

atti del congresso
Trento, 19-20 novembre 2010

a cura del CESMAR7

Quinto congresso internazionale
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materiali e metodi nel restauro
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SEZIONE POSTER

From the laboratory to the restorer studio. Practical inpaint applications with commercial colours of synthetic resins

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Abstract

The aim of this research is to evaluate the colour stability and solubility changes of some of the more frequently used materials that, nowadays, are available for restorers to carry out inpainting of missing areas during the conservation treatment.

First of all, results obtained from subjecting the samples to artificial ageing are presented and, secondly, the conclusions observed during the practical application of such materials on mock-ups are presented as well, in order to correlate the experimental data obtained in the laboratory to the real working conditions in conservation studios and provide information on technical characteristics and behaviour of such commercial products. The pictorial retouches on works of art are also included of those materials that better results were obtained in both the laboratory and practical application.

Introduction

In the field of restoration, the reintegration of colour is aimed at re-establishing a chromatic or a chromatic-formal union among the areas affected with the original surrounding fabric. This phase should be planned from two fundamental concepts: reversibility and the distinction between original and addition.

In practice, the choice is to turn to materials offered by the industry which, nevertheless, not always satisfy the requirements of stability, endurance and compatibility that are required[1-2], and they can therefore give rise to processes of degradation, frequently with severe consequences for the work of art.

Ruhemann[3] pointed out the inexistence of an ideal binder, given that they all present some problem of hue, of ageing, or of reversibility. But recently published references on the comparative study of the materials employed in the phase of reintegration with colour, offer interesting results regarding their behaviour through time.

Synthetic resins of low molecular weight have been used in the field of conservation, due to their application properties and optical qualities similar to the natural resins, which allow for a high saturation of the colours. In year 2000, René de la Rie[4] and his team researched the preparation of a retouch paint that would comply with these requirements. After a series of experiments, carried out in collaboration with the National Gallery of Art, Washington, it was proven that the urea-aldehyde resins offered the best properties for use as colour binders for pictorial retouch.

The Gamblin colours[5] -according to the commercial brand- are elaborated with Laropal A81 resin, mineral alcohols, and light-resistant pigments, they do not contain additives and only the organic pigments have incorporated small quantities of hydrated alumina, to adjust their colouring power. Due to their low viscosity, these paintings have optical qualities similar to the colours with natural resins and their use is especially indicated in cases where relatively high colour saturation is required. In practice, the colours bound with Laropal A81 are soluble in solvents such as isopropyl alcohol, acetone, ethanol, and Mineral Spirit; moreover, they have a good covering power, and offer a great versatil-

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ity in the achievement of a variety of effects and a limited colour change when drying. Several PVAc copolymers with certain qualities are very stable and remain soluble in alcohols, ketones and aromatic hydrocarbons. Clark and Ives[6] made the first trials with solutions and dispersions with PVAc as binder for retouch paints. The colours for conservation by Golden -as the manufacturer indicates-, bound with acrylic resin, have a high viscosity, are very brilliant and stable, dry quickly and form durable films, with resistance to ultraviolet light and an excellent chemical stability against acids and alkali. They remain soluble in Mineral Spirit.
Synthetic resins based on polycyclohexanones (ketonic resins), which application to reintegration was published by Straub[7], have as inconvenient their tendency to become more insoluble in the initial solvents, since they become more polar. A colour range for restoration by the brand Maimeri is composed -as appears in its technical files- by stable pigments, bound with a ketonic resin and selected hydrocarbons, with the goal of offering the highest qualities of reversibility in time and resistance to ageing that is more suitable for all sorts of interventions on coatings with modern synthetic varnishes. Likewise, the retouch colours of the brand RestaurArte -as the manufacturer states-, are products elaborated with very pure pigments, finely ground and with a high covering power. The binder employed is a ketonic resin solution in turpentine essence, chosen as a function of various factors, such as: optimal reversibility; a very high resistance to yellowing and a low tendency to acidity; and a good stability during storage.

From the laboratory...

Methodology

Preparation of the samples

The choice of the colour palette to carry out this research was based on a practical criterion of selection derived from the colours commonly used in institutions and conservation studios at present. Therefore, a palette of ten colours had been selected of the four commercial paints: Gamblin (based on urea-aldehyde resin), Golden (containing acrylic resin), Maimeri (made of ketonic resin), and RestaurArte (based on ketonic resin too). In this research, colours in tube (which is the case of Maimeri, and of RestaurArte) as well as in glass jars (Gamblin, and Golden MSA) have been used.
Only commercial paints were studied due to the practical application of most conservators in Spain, unlike other countries as Italy or France, for example, where own pallete was made of dry pigments mixed with a resin.
The initial attempt was to compare the same pigments for all four commercial paints (Fig. 1). Nevertheless this was not possible in all cases due to the unavailability of products with the same composition of pigments for the different brands.
To proceed with the study, 40 plates were prepared, using glass as support, with dimensions 100 x 65 x 4 mm, as states the standard UNE-EN ISO 11341. All of the plates were cleaned with ethanol, as a process previous to the application of each of the colours, which was done, once mixed with their corresponding thinner, with the help of a standard paint extender of an invariant thickness (ASTM D823-53), by the brand Neurtek, and obtaining a thickness of film of 120 µm.

Artificial ageing process

Glass plates were subject to an accelerated ageing process, following the ASTM D4303-3 standard, introducing them in a Solarbox accelerated xenon light fastness and weathering test chamber, model 3000e RH.
The factors considered for the assessment of the deterioration have been the light radiation, the temperature and the relative humidity. Certain protocol was followed, with the following conditions, so this study can be reproducible and enables a correct interpretation of results:

- UV filter (window glass): 310 nm.
- Irradiance: 50 W/m^2
- BST temperature: 50° C ± 2° C
- Air chamber temperature: 30° C
- Chamber RH: 50%
- Duration of the test: 2 trials of 200 hours each.

Assessment method of chromatic changes

After artificial ageing tests and with the aim to evaluate possible colour changes of the selected paintings, the colour scale, the testing standard and the equipment used were set. The colorimetric measurements have been carried out with a spectrophotometer of the brand GretagMacbeth®, model ColorEyeXTH, with a primary illuminant D65. For each paint, a sample was kept as control. The measurements were taken from the control samples and after, 200 hours and 400 hours of accelerated ageing. Based on the standard employed, ASTM D4303-3, the evaluation of the colour differences (ΔE^*_{ab}) in the three observation times, has been made according to the measurements of trichromatic coordinates, within the 1976 CIELAB colorimetric space (L* = lightness; a*= red/green axis; b*= blue/yellow axis). The limit of colour difference for a painting to be accepted by the standard is marked in the value 4.

Appraisal method of solubility changes

Tests of solubility were carried out on two colours: one of the most stable, as is white, and one of the least, red lake, so that another 8 plates were prepared, conducting a study of both optical and FTIR, with a Thermo Scientific Nicolet™ 380 equipment.
To estimate the variation of solubility in the paintings studied after undergoing the diverse periods of accelerated ageing, the solubility of these paints has been taken as reference.
To this end, a test of solubility has been used, based on ligroin and ethanol in three different polarities: low (LE1), intermediate (LE5) and high (LE9).

Experimental results, interpretation, and discussion

Application of the materials on the support plates

Using the corresponding thinners of the various commercial brands under study, the paints were previously mixed to obtain a correct homogeneity of the paste, before proceeding to spread them on the glass supports.
It has been proven how certain colours show a greater ease of application than others, and, in some cases, the presence of an excess of binder has been observed, or, even, of a compound that presented it in two phases, which made the mixing process of the colour somewhat more difficult.
The application characteristics of the paints tested are expressed qualitatively in the table (Fig. 2), according their mixing and dilution. The jars of the Gamblin colours presented mixtures of little homogeneity, so that they have to be mixed properly before use. In the case of Golden, it is observed that the paints have a high density in the glass containers, and required therefore a lengthier mixing process. In both commercial brands, the dispersion of the pigments is better than that of the colours bound with ketonic resins. In RestaurArte, some colours, in tube, contain an excess of binder, which causes an increased difficulty in achieving a uniform distribution of the content in the container, especially both raw sienna and raw umber. Finally, this excess of binder is not observed in Maimeri, which contain more compact paints.
Once the colours have been extended and dried on the glass plates, it is worth noting that there are considerable differences among the various pigments; e. g., whites show a lower proportion of lumps than red lakes, in all the brands under study. Observed under the binocular magnifying glass, the retouch paints by Maimeri and by RestaurArte have a marked surface relief, more pronounced in the second case. The acrylic paints, by the commercial brand Golden, and those of aldehyde resin, by Gamblin, show smoother surfaces in most of the colours.

Lightness

The results of colour difference (Fig. 3) are laid out, making a distinction between lightness and colour variation. Despite these data being intimately related in the assessment system employed, they are displayed separately, with the aim of better explaining the changes occurred in each of the colours under study, and of proceeding to the comparison among the several commercial brands.
The results in term of lightness (Fig. 4) show the variations of all colours tested after artificial ageing, and reveal that:

- Golden was the brand that changed the less,

- In general, Golden and RestaurArte paints darken for most of their paints,
- On the contrary, Maimeri evidences the most significant lightening for many of its colours.

The greatest differences in lightness in the various colours under study are found in blue (9), raw umber (7), and cadmium yellow (2). The rest of the samples show likenesses regarding their luminosity, and the cadmium red (3) is the colour with a most homogeneous value in this factor, in all the four commercial brands studied.

Parameters a* and b*

The values in the axis a* and b* obtained in the glass plates prior to ageing show great differences in colour in the various ranges of the commercial brands under study. Therefore, these values after 400 hours of artificial ageing (Fig. 5) indicate that there are colours that have been changed most notably, emphasising permanent carmine of Maimeri.

Uniting both coordinate axes, colours appear with relevant differences with respect to other commercial brands within the same range:

- The most orangey are found in cadmium paints by Gamblin and in brown madder and raw umber by RestaurArte,
- The most green-bluish are alizarin crimson permanent and Indian red by Gamblin, titanium white by Golden, and cadmium red medium by RestaurArte,
- The most violet appear in cobalt blue by Maimeri and in chromium oxide green by RestaurArte;
- The most greenish are ultramarine blue by Gamblin and raw sienna by Maimeri.

All the data shown above must be taken into consideration by the restorer when facing the process of chromatic reintegration, since they can serve as an important reference in the search for a better adjustment of the loss with the original colours that surround it.

Tristimulus values

The last part of this phase corresponds to the results of colour difference (Fig. 6). Observing the value of colour difference framed in red, the maximum value that allows the standard for determining optimal one colour, we realize that most tested paints are below this value, both 200 hours and 400 hours of artificial ageing. The only brand that shows all the colours within the standard is Golden.

Solubility changes

From the initial results, that corresponds to the visual examination (Fig. 7), we can indicate that Golden seems to be the most stable, followed by Gamblin colours. The results of FTIR were compared also for each of the materials tested, at time zero, 200 and 400 hours of artificial ageing (Fig. 8). We would like to focus on Golden, where the mixture of less polar solvents solubilizes the product during the entire test.

Conclusions

We can draw the following conclusions about the colour differences:

- Between the tested trademarks, Golden could be considered the most suitable for inpainting,
- Ketonic resins, both Maimeri and RestaurArte, have shown less stable to light degradation,
- In general, colours with the worst values of colour difference were: red lake, raw sienna, and both blues,
- By contrast, those colours with better light stability after 400 hours of artificial ageing were: white, raw umber, and chromium oxide green.

Respect to solubility changes, it can be concluded that after 400 hours of accelerated ageing, Gamblin and Golden samples could be solubilized in less polar solvents; whereas Maimeri colours did it in the intermediate and high polarity solvents. In the case of RestaurArte, any of the three solvents mixtures selected was effective.

Significant influence was also shown on changes in solubility of the paints along ageing, as expected, about their components as pigments, fillers or additives, as well as the binder used.

... To the restorer studio

Methodology

Preparation of mock-ups of picture plates

After completing the experimental in the laboratory, a second stage of the project was developed and it consisted of the practical application of each of the tested materials. The objective was to correlate the experimental data to conservator's working conditions and trying to understand the behaviour of selected commercial products.
A series of mock-ups were prepared for this, by glueing plates of paintings on panels for each of the materials. Equivalent losses of medium size were and were filled in with a synthetic filler.
The lower half of all simulated losses was inpainted with Winsor & Newton water-colours, leaving a final adjustment layer to be carried out with other materials, in the Italian traditional way. The upper half was retouched directly using only a commercial paint over the white filler, in order to check if such materials could behave equally not having a watercolour layer below, since that could be interesting for some works of art, mainly contemporary ones.

Preparation of mock-ups of contemporary art

To complete this work, mock-ups were prepared, consisted of canvas mounted on a wooden stretcher and then a mixed painting technique was applied. A loss simulating a strip was made and filled with three different fillers: Modostuc and two more made from an acrylic resin (Plextol B-500) and a vinyl one (Vinavil 59). When inpainting some contemporary art paintings, as monochromes, *Selezione cromatica* can't be made due to a too vibrant brushstrokes. So that glazes could be a good option in these cases. This is the following study made.
For the inpaint process the two brands that showed the best results in the laboratory, Gamblin and Golden, were selected.

Selection of the solvent

Only one solvent was decided to be used in all the mock-ups, being the starting point those recommended by the manufacturers. Gamblin proposes both low-polarity solvents, as White Spirit, Mineral Spirit or ligroin, and polar solvents as isopropyl alcohol, acetone or ethyl l-lactate; Golden suggests the use of Mineral Spirit or solvents with a low proportion of aromatic hydrocarbons; the other two brands, Maimeri and RestaurArte, advise the use of both petroleum essential oil and turpentine essence. However, from the outset, the latter solvent was not considered not only for the problems that can cause to the work of art but also for its toxicity.
Once the main properties of the solvents mentioned had been analysed (Fig. 9), it was decided to use ethyl l-lactate, described nowadays as "green solvent", because it could thin to a greater or lesser extent all retouching paints under study, and it also shows significantly lower toxicity compared to other solvents traditionally used in this stage of restoration. The drying process of this solvent could be accelerate by mixing acetone, up to a ratio of 1:1 v/v, to facilitate the applications of strokes or glazes during the inpaint process.

The final varnish selected

The varnish used for mock-ups was Regal Varnish, consisting of a low molecular weight resin with well suited characteristics for this field:

- High resistance to ageing by the addition of Tinuvin 292,
- Optical properties similar to natural resins,
- Low viscosity, which implies an excellent adaptation to the irregularities of the layer,
- Glass transition temperature of 33° C, which prevents the absorption of dust particles.

This coating film is only suitable as final varnish and not as an intermediate coating during inpainting, because it is soluble, in medium-to-low polarity solvents, which are generally used during retouching.

Experimental results, interpretation, and discussion

Mock-ups of picture plates

Two of these mock-ups have been chosen. In all cases, the same colours and the same order were used. For the inpaint of the plates on blues (Fig. 10), the colours used, from bottom to top, are raw sienna, ultramarine blue, and alizarin crimson. Meanwhile, reddish plates (Fig. 11) were inpainted with cerulean blue for the first layer, alizarin crimson for the intermediate one, and finally with cadmium red. Sometimes a final layer of a black colour is necessary in order to obtain the optimal level of saturation.

Gamblin

In Gamblin colours is to mention the brightness of the painting, since it is the brightest colours of those studied, although it can be used as a matt paint. Also mention the overlaying, possible as indicated, although it will be discussed in depth at the end of this phase.

Regarding the application, it is important to say that it is necessary to mix the paint well into the jar before use, because it tends to appear dissociated due to the low polarity of the aldehyde resin.

Golden

As for the Golden paints, the problems of overlaying are to mention, as each new layer can remove the immediately below. The manufacturer recommends an isolated layer of Golden Polymer Varnish, a water-based acrylic varnish that is removed by alkaline solvents.

It also should be noted that colours are fairly transparent, making it difficult to get a proper retouch with well-defined lines, because the layers tend to blend into each other, as pointed out. It is therefore considered more suitable as final tonal adjustment on a watercolour base.

Maimeri

We will not go in detail into Maimeri colours in terms of handling properties, because of its similarity of Maimeri paints made with mastic resin that are well known in the field of restoration. It should be mentioned that overlaying is possible with the diluent selected, providing a glossy finished surface.

Restaurarte

There are several colours in RestaurArte -titanium white, cadmium red medium, brown madder, Pozzuoli earth, raw umber and ultramarine blue- which show an excess of binder on the tube so that the brushstrokes are not homogeneous. Raw umber is greener than usual with the adjustment problems that can lead to the choice of this material.

Mock-ups of contemporary art

Golden

This paint with Ethyl l-lactate thinner, as told before, show a slightly opaque colours, so overlaying glazes are needed, but again the removal of the film underneath is still a problem, and an evaporation time is needed in between the layers or, better, an isolation coat should be applied (Fig. 12).

Gamblin

The overlaying is easier than in Golden mock-up, although there is still some risk to remove the underlying coats. This risk is eliminated if other solvents were used, as ligroin, Shellsol D40 or another solvent also recommended by the manufacturer (Fig. 13).

Conclusions

As final conclusions in this stage of the research, it could be said that Maimeri showed appropriate working properties. Gamblin colours are also suitable for this process although require precise brushstrokes and control of drying time, due to the ethyl l-lactate, in between the applied layers of colour to avoid removing the underlying layer; when this material has been used as final inpaint on a previously retouch with watercolours it has been observed more easily at work, achieving a top-quality finish. In the case of Golden paintings, one of the greatest difficulties is the low opacity and the very intense colour range that seems that could be much more suitable for retouching contemporary art.

Carrying on with the research

Given the less easy handling properties of Golden due to the solvent, ethyl l-lactate, the research continued until obtaining its suitable solvent, so that Mineral Spirit is not available in Europe, conducting several tests with different solvents, and taking into account their boiling points, their aromatic hydrocarbons percentages, their polarity and their relative evaporation rates (Fig. 14). After these several tests, shown below, this problem hasn't been solved, so that this phase of the research is not still finished.
There is a great confusion on the different names in the commerce, as Mineral Spirit, White Spirit, Stoddard, and so on, that seem to be the same but in practice they don't work in the same manner. This is the problem shown in this case.
The difference in the aromatic hydrocarbons both Mineral Spirit, in USA, and White Spirit, in Europe, seems to be the responsible of not working in Golden paints. Although ethyl l-lactate could thin more or less the colours, and the research could be carried out, the change of polarity is very high, so that the decantation of the paint. Also the very slowly evaporation of ethyl l-lactate, as shown before, provide a high risk to remove the underlying layers during inpainting.

Iso-octane + Benzyl alcohol

First alternative was iso-octane, as being the most non polar solvent, with a mixture of benzyl alcohol to increase the boiling point and the polarity. Also while iso-octane has no aromatic hydrocarbons in its composition, benzyl alcohol has aromatic alcohol that can provide certain percentage in these compounds (Fig. 15).
The mixture of 5% of benzyl alcohol in iso-octane cannot thin the paint. When increasing benzyl alcohol until 10% at beginning can thin the paint but after a few seconds paint decants. If benzyl alcohol increases until 15% can made a mixture more or less homogeneous and strokes are possible in this colour. But testing with other colours, this mixture solvent provides no homogeneous paint, as in ultramarine blue.

Shellsol D40 + Ethyl L-lactate

This solvent is another alternative for Mineral Spirit. The paint is thick, the pigments decant and the brushstrokes are nor possible, maybe due to the fast evaporation, so that this solvent is not similar as Mineral Spirit either.
A mixture of Shellsol D40 and Ethyl l-lactate was carried out (Fig. 16). The mixture of 10% of ethyl l-lactate in Shellsol is acceptable but strokes are not possible so that paint has no body although testing with cadmium. An increasing until 20% of ethyl l-lactate makes a good mixture but only one stroke is possible at the same time, so that *Selezione cromatica* is not good. If ethyl l-lactate is increased until 30% the paint decant again as in the first step.

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Notes

1. Szmit-Naud, E. *Research on materials for easel painting retouches*, vol. 1. The Picture Restorer 2003, 23, pp.5-10.
2. Szmit-Naud, E. *Research on materials for easel painting retouches*, vol. 2. The Picture Restorer 2003; 24, pp. 5-9.
3. Ruhemann, H. *Visible retouchings*. In Internacional Congreso, Internacional Museums Office, Rome, 1930; *Technical and Ethics of Retouching. In The Cleaning of Paintings*, Hacker Art Books, New York, 1968. pp. 240-268.
4. De la Rie, R. E. Quillen Lomas, S. Palmer, M. Deming Glinsman, L. Maines, C. M. *An investigation of the photochemical stability of urea-aldehyde resin retouching paints: removilitity*

tests and colour spectroscopy. In Tradition and Innovations. Advances in Conservation, IIC Melbourne Congress, London, 2000, pp. 51-59.

5. Leonard, M. Whitten, J. Gamblin. R, De la Rie, E. R. *Development of a new material for retouching. In Tradition and Innovations. Advances in Conservation*, IIC Melbourne Congress, London, 2000, pp. 111-113.
6. Clark, W. Ives, H.E. *Use of polymerysed vinyl acetate as an artist's medium.* In Technical Studies in the Field of Fine Arts, 1935, 4:, pp.36-41.
7. Straub, R.E. *Retouching with synthetic resin paint.* In The Museums Journal, 1962, 62, pp. 113-119.

Fig. 1. List of colours selected in all commercial brands studied.

	GAMBLIN	GOLDEN MSA	MAIMERI	RESTAURARTE
	Urea-aldehyde r.	*Acrylic resin*	*Ketonic resin*	*Ketonic resin*
1	Titanium white (PW6)	Titanium white (GMSA380)	Titanium white (018)	Titanium white (01)
2	Cadmium yellow medium (PY37)	Cadmium yellow medium (GMSA130)	Cadmium yellow lemon (082)	Cadmium yellow medium (04)
3	Cadmium red medium (PR108)	Cadmium red medium (GMSA100)	Cadmium red medium (228)	Cadmium red medium (12)
4	Alizarin crimson permanent (PV9, PR149, PB29)	Quinacridone red (GMSA310)	Permanent carmine (167)	Brown madder (20)
5	Indian red (PR101)	Red oxide (GMSA360)	Indian red (242)	Pozzuoli Earth (13)
6	Raw sienna (PBr7)	Raw sienna (GMSA340)	Raw sienna (161)	Raw sienna (09)
7	Raw umber (PBr7)	Raw umber (GMSA350)	Raw umber (493)	Raw umber (25)
8	Chromium oxide green (PG 17)	Chromium oxide green (GMSA060)	Chromium oxide green (336)	Chromium oxide green (16)
9	Manganese blue (PB 33)	Cerulean blue (GMSA050)	Cobalt blue (372)	Cerulean blue (19)
10	Ultramarine blue (PB29)	Ultramarine blue (GMSA400)	Ultramarine blue (390)	Ultramarine blue (18)

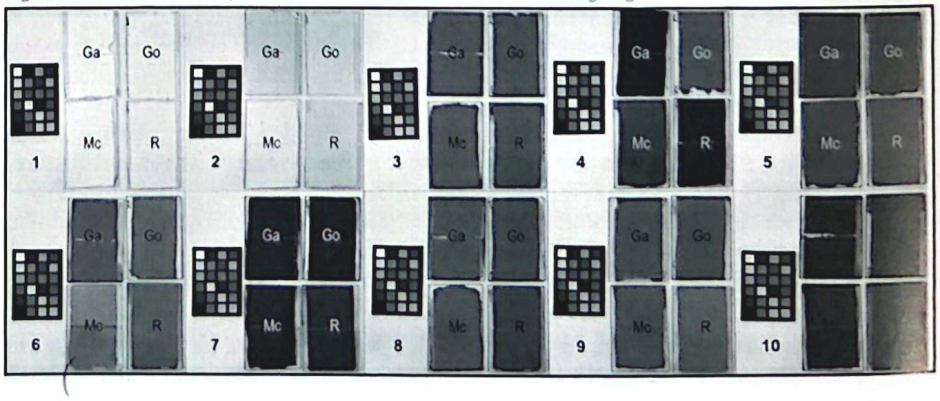
Fig. 2. The application characteristics of the paints tested.

	MIXTURE				DILUENT			
	Ga	Go	M	R	Ga	Go	M	R
1	C	C	D	C	B	C	A	B
2	A	B	B	D	D	B	B	D
3	D	A	B	C	C	B	B	C
4	A	D	A	D	B	C	D	D
5	C	C	C	C	D	B	B	C
6	B	B	B	D	A	B	C	D
7	B	A	A	C	C	B	D	C
8	A	D	B	C	C	D	C	C
9	A	B	B	B	A	C	C	B
10	C	B	B	A	D	B	A	A

Ga. Gamblin	Go. Golden	M. Maimeri	R. RestaurArte

A – The best	B – Better	C – Good	D – Regular

Fig. 3. The final state of the plates after four hundred hours of artificial ageing.



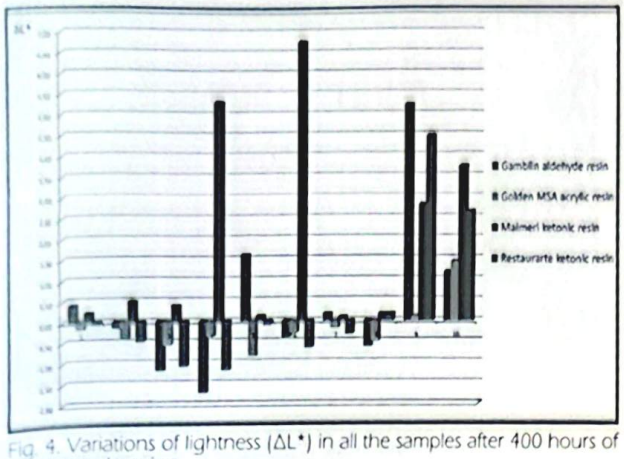


Fig. 4. Variations of lightness (ΔL*) in all the samples after 400 hours of accelerated ageing.

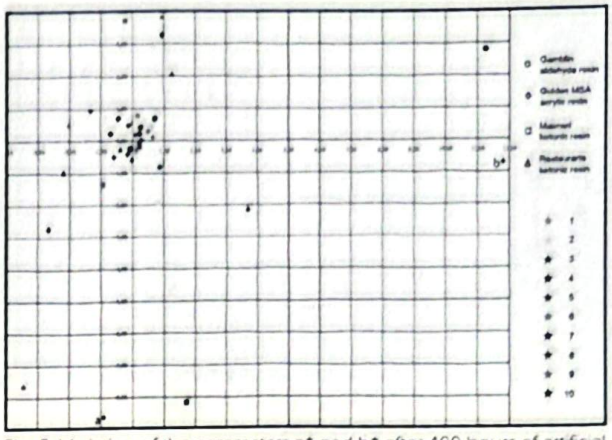


Fig. 5. Variation of the parameters a* and b* after 400 hours of artificial ageing (Δa* and Δb*).

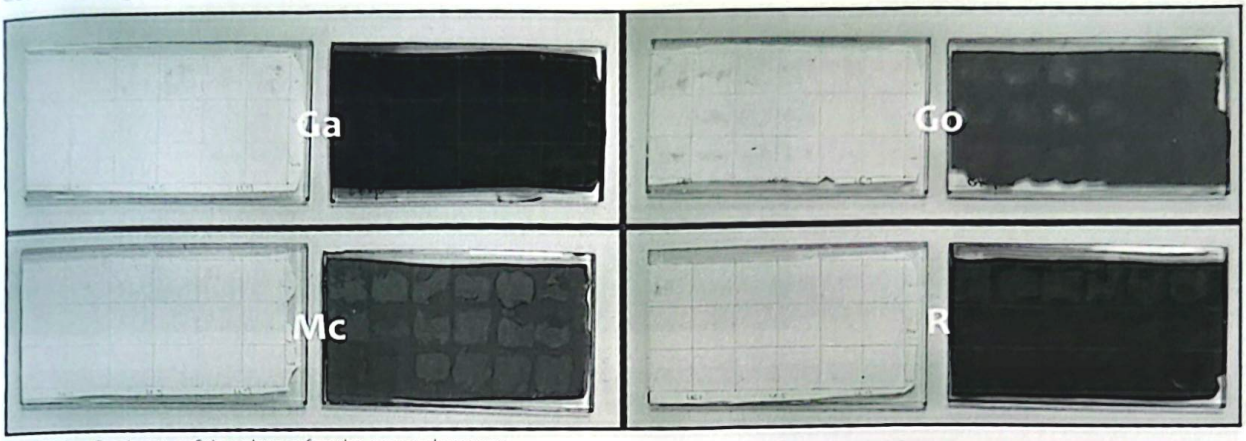


Fig. 7.The final state of the plates after the removal process.

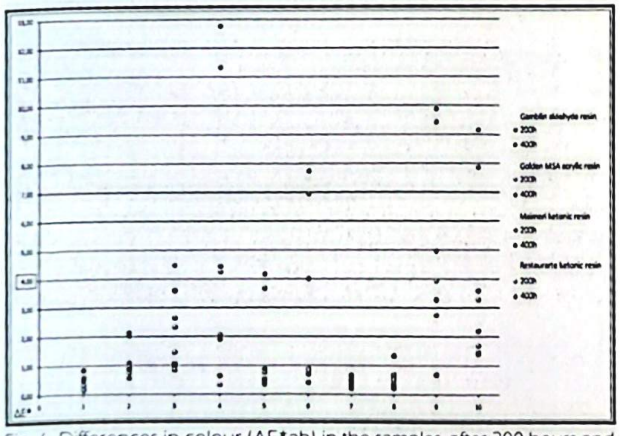


Fig. 6. Differences in colour (ΔE*ab) in the samples, after 200 hours and after 400 hours of accelerated ageing.

To the right:

Fig. 8. Data obtained from FTIR analysis of the solubility tests.

Sotto:

Fig. 9. Certain chemical properties more significant of the solvents recommended by the manufacturers of the paintings under study, and also the solvent selected for this research. Data shown are obtained of the International Chemical Safety Cards.

	SAMPLES	MIXTURE OF SOLVENTS	HOURS 0	200	400
Gamblin - Ga	1. Titanium white	LE1 - 90:10	++	+°	-
		LE5 - 50:50	+	++	+
		LE9 - 10:90	+	++	+
	4. Alizarin crimson permanent	LE1 - 90:10	+	+	-
		LE5 - 50:50	+	+	+
		LE9 - 10:90	+	+	+
Golden - Go	1. Titanium white	LE1 - 90:10	+	+	++
		LE5 - 50:50	+°	++	+
		LE9 - 10:90	-	-	+°
	4. Quinacridone red	LE1 - 90:10	+	++	+
		LE5 - 50:50	++	++	++
		LE9 - 10:90	-	+°	+°
Maimeri - Mc	1. Titanium white	LE1 - 90:10	+	-	-
		LE5 - 50:50	+	+	+
		LE9 - 10:90	+	++	++
	4. Permanent carmine	LE1 - 90:10	+°	+°	-
		LE5 - 50:50	+	++	-
		LE9 - 10:90	-	++	++
RestaurArte R	1. Titanium white	LE1 - 90:10	-	-	-
		LE5 - 50:50	-	+°	+°
		LE9 - 10:90	+°	+°	+°
	4. Brown madder	LE1 - 90:10	-	-	-
		LE5 - 50:50	+°	-	-
		LE9 - 10:90	+°	-	-

Abundance order of signals that indicate the presence of resins:
+° little signals that the product was extracted on the swab
+ low extraction
++ higher extraction

	DENATURED WHITE SPIRIT D40	MINERAL SPIRIT	PETROLEUM ESSENTIAL OIL	ETHYL L-LACTATE
Compound	Mixture of aliphatic hydrocarbons denatured with dichloropropane	Mixture of hydrocarbons from distilled petroleum	Mineral essential oil distilled from refined petroleum	Lactic acid ester
Density	0,78 kg/l a 20° C	0,79 kg/l a 20° C	–	1,03 kg/l a 20° C
Solubility	Water-insoluble (20° C)<10%	Water-insoluble (20° C)	Soluble in mineral turpentine	Water (10% - 25° C); paraffin oils and most ketones, esters and hydrocarbons
pH	–	–	–	4 (a 20° C)
Boiling point	145° - 200° C	150° - 200° C	140° - 165° C	154° C
Flash point	38° C	38° C	< 20° C	46° C
Relative evaporation rate (Butil acetate = 1)	0,11	0,08	0,48	0,22
TLV	100 ppm	100 ppm	100 ppm	150 ppm

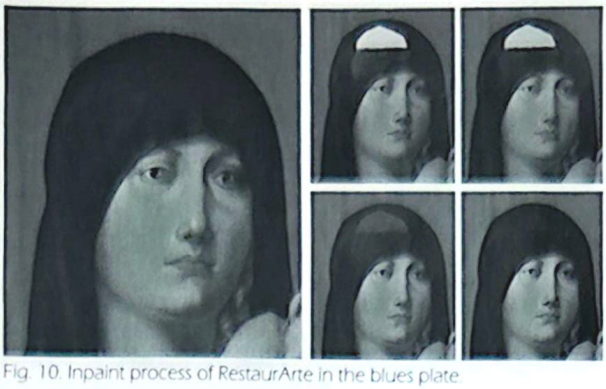


Fig. 10. Inpaint process of RestaurArte in the blues plate.

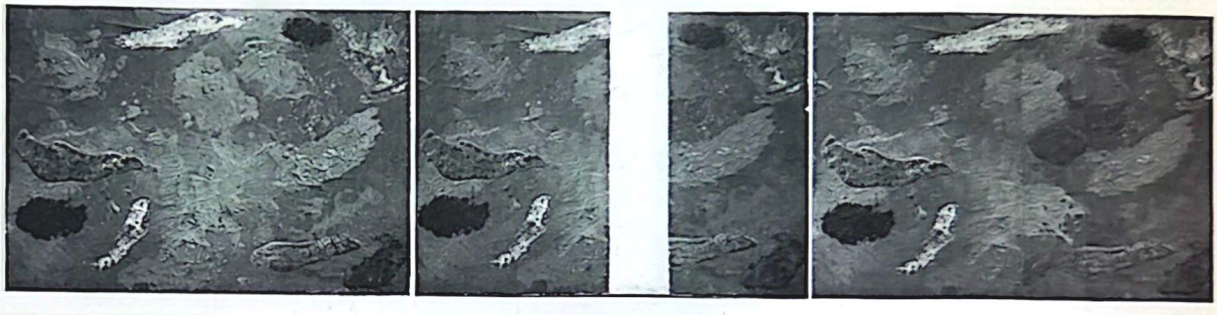
Fig. 11. Series of the Selezione cromatica in the reddish plate made with Maimeri paints.

To the right:

Fig. 12. Mock-up of contemporary art with a Golden retouch.

Below:

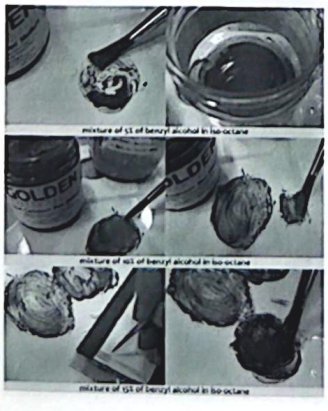
Fig. 13. Study process of inpaint in a mock-up with Gamblin colours.



	MINERAL SPIRIT	WHITE SPIRIT	ETHYL L-LACTATE	ISO-OCTANE	BENZYL ALCOHOL	SHELLSOL D40
Boiling point	149-204° C	145-250° C	154° C	98-99° C	205° C	162-181° C
Aromatic hydrocarbons	0,1%	5-20%	0%	0%	Aromatic Alcohol	<0,01%
Polarity: F_d	90	90	44	100	48	90
Relative evaporation rate (Butil acetate = 1)	ca. 0,08	0,15	-	<1	0,13	0,23

Above:

Fig. 14. Some chemical properties of the solvents recommended by Golden to thin their acrylic paints, and the chose ones in the study. Data shown are obtained of the International Chemical Safety Cards.



To the left:

Fig.15. Different views of the several tests made on Golden paints with a mixture, in three percentages, of iso-octane and benzyl alcohol.

To the right:

Fig.16. Trials made on Golden colours with Shellsol D40, and a mixture of this solvent with three different percentages of ethyl l-lactate.