# UV-VIS SPECTROPHOTOMETRIC STUDY ON THE SUITABILITY OF TREATMENT WITH ORGANIC CONSOLIDANTS USED IN THE CONSERVATION OF A MODERN SCULPTURE

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ABSTRACT: *This paper is a continuation of a previous study that was carried out to determine the suitability of a series of organic consolidants employed in the process of conservation-preservation of a modern sculpture (1). The work is a sculpture carved out of phenolic foam (2) with a series of particularities that makes it unique and unrepeatable.*

*Spectral data was analyzed using measurements made on this material after it had been treated with various organic consolidants, using different concentrations and methods of application. Measurements were also taken after 3600 hours of UV light accelerated ageing.*

*UV-Vis was selected because it is a non-destructive technique of great utility for making quantitative assessments, by means of laboratory measurements, of which are the most appropriate materials to preserve the artistic work and also what materials to use in different conservation treatments (in terms of the variations in colour that can occur after the material has been applied or predicting its chromatic resistance over time).*

KEYWORDS: Phenolic Foam, spectrophotometry, preventive methods, consolidation, contemporary art

## INTRODUCTION

There are numerous interventions being employed nowadays on contemporary art works. These treatments present a series of alterations owing to the properties of the substrate as well as because of the stresses to which they are subjected. For this reason, to define which treatment processes to use we must employ prior analytical methods that help predict any possible changes that may develop over the lifetime of the object.

The sculpture under examination was created during 1998-99 by the Valencian artist, José Romero, while living in New York City. The piece is entitled ¨Voces Cautivas¨ and consists of 150 small figures carved out of phenolic foam. The approximate dimensions of these figures are: 25-30 cm x 8-10 cm x 4-6 cm (HxWxD).

The state of preservation of these works in a reflection the inherent characteristics of the material as well as being the result of handling during exhibition and transport. The pieces were observed to be very friable with some volumetric losses of material (3).

In this work, the use of visible spectrophotometry helped to determine (by systematic comparisons of their chromatic stability) changes in the colour of the material. These changes arise long before they can be detected by the human eye. If changes are detected early enough it is easier to perform the necessary conservation interventions before the deterioration becomes irremediably visible.

## METHODOLOGY

### A. Materials:

The consolidants used were supplied by CTS and are described below:

- *Paraloid B-82®* (Methyl methacrylate acrylic resin), dissolved in ethanol and distilled water (9:1 vol.)
- *Plextol B-500®* (pure acrylic thermoplastic resin) dissolved in distilled water
- *Mowilith SDM-5®* (co-polymer of vinyl acetate and acrylic ester) dissolved in distilled water

- Two methods of application were selected, namely partial immersion and vacuum impregnation at two concentrations (5 and 10%).

### B.- Instrumental

Spectral data were obtained using a Minolta CM-2600d spectrophotometer. The standard illuminant CIE $D_{65}$ (daylight, colour temperature 6500° K) and the 10° standard observer were employed. Data was recorded with the specular component (SCI) that minimizes the influence of the conditions of the measurement surface and with 100% ultraviolet. The measurement area that was selected was 8 mm Ø as the samples were of a sufficient size to make it possible to obtain an average value of the area. The diffuse measurement geometry was 8 (d/8) and the light source consists of three pulsed Xenon lamps with an integrating sphere (of Ø52) coated with $BaSO_4$. The wavelength range and pitch used were 360-740 and

Figure 1. Details from the sculptoric group "Voces cautivas" by Valencian artist José Romero, New York, 1998-1999

10 nm respectively. The instrument has a reflectance range of 0-175% and a resolution of 0.01%. The standard deviation is within 0.1% and 0.04 for spectral reflectance and the colorimetric values of $\Delta E^*_{ab}$ (CIE 76) values respectively.

**C.- Procedure:**

1.- Preparation of the test specimens and consolidation methods:

Test specimens were prepared using new phenolic foam as well as the original used by the artist. 24 (4cm³) cubic test specimens were prepared.

**Table 1** summarizes the type of method of application and the different consolidants used in this study. For the two classes of phenolic foams used, three types of consolidants with different concentrations were applied by either partial immersion or vacuum impregnation

| Methods of application | Partial immersion Foam new/ original | | Vacuum impregnation Foam new/ original | | Dissolvent |
|---|---|---|---|---|---|
| Type of consolidant | Concentration % | | Concentration % | | |
| Mowilith SDM-5® | 5 | 10 | 5 | 10 | distilled H₂O |
| Plextol B-500® | 5 | 10 | 5 | 10 | |
| Paraloid B-82® | 5 | 10 | 5 | 10 | H₂O/Ethyl alcohol (1:9) |

Application by partial immersion was carried out using the following procedure:

5 minutes in partial immersion to ¼ of the height of the sample followed by total immersion.

The application procedure by vacuum impregnation was determined after conducting a series of preliminary tests. The resulting method is presented below.

  1- Vacuum extraction of the air from the porous network during 5 minutes.
  2- Impregnation of the consolidant by percolation for 40 minutes at a pressure of 200 mm Hg.
  3- Impregnation by partial immersion (1/4) at 200 mm Hg for 15 minutes.
  4- Drying of the samples at room temperature (19-23ºC).

2.- Preparation of the samples for instrumental analysis:

Test sample cubes were divided into two parts with each internal face facing the UV-light radiation panel, at a distance of 20 cm. Periodically spectral data was collected for each of the test specimens using the instrument described above.

**RESULTS AND DISCUSSION**

The two main objectives of this work were:

  1.To quantify the chromatic variation experienced by the test specimens after the application of several consolidants.

  2.To quantify the colour change of such specimens after exposure to UV-light radiation for a 3600-hour period.

Two groups of samples are described in this work and they consisted of the original phenolic foams employed by the artist (old) as well as test specimens made out of the same material that has been recently acquired (new). For this reason, the results were divided into two groups:

A) New foams
B) Old foams

The comparison study of these two types of foams is presented below.

A thorough assessment was also made of the total colour variation and how these changes affect each one of the parameters that define colour (brightness, chroma and tone).

**1. Chromatic variation observed in test specimens after being treatment with several consolidants.**

1.1. Total colour differences (ΔE*):

A) New foams:
Total colour difference values (ΔE*) are in the range of **2.4** [PA(10)brush, br and M(5)impregnation, im] to **9.5** [P(10)im]

Test specimens consolidated with PARALOID showed the smallest change **(ΔE*→2'4 to 5'3)**. These are followed by the ones treated with PLEXTOL **(ΔE*→5'8 to 9'5)** and finally those treated with MOWILITH showed a greater change **(ΔE*→3 to 8'1)** and are considered to have less colour retention.

B) Old foams:
Total colour difference values (ΔE*) oscillate between **3'6** [M(5)im to PA(10)br M(10)im] and **9.4** [P(5)im]

Small changes were observed in samples that were consolidated with MOWILITH **(ΔE*→3'6 to 6'7)**, followed by the ones treated with PARALOID **(ΔE*→5'3 to 8'5)**. Finally, samples treated with PLEXTOL show a greater change **(ΔE*→5'3 to 9'4)**. Thus, PLEXTOL is considered to be a poor performer in terms of its colour retention.
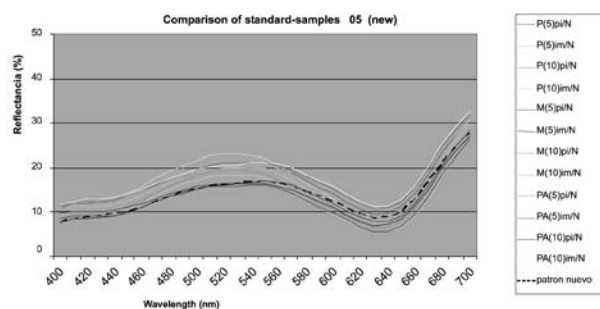
Figure 2.- Spectra of the consolidated samples compared with a new foam reference sample
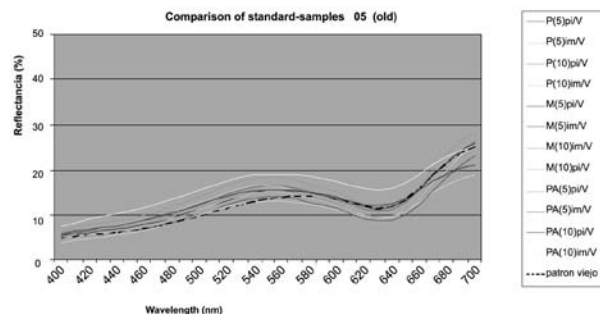


Figure 3.- Spectra of the consolidated samples compared with an old foam reference sample
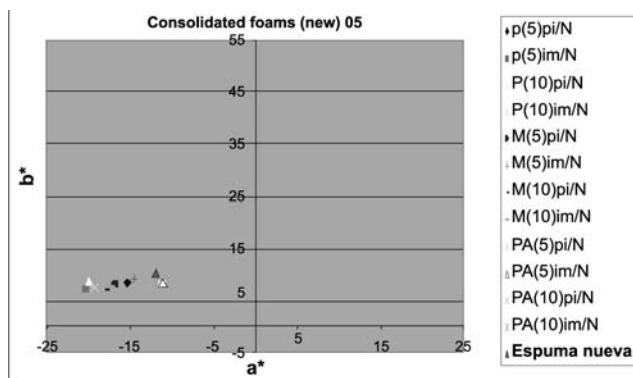


Figure 4. Chromaticity diagram showing a comparison between new foam consolidated samples and the new foam reference
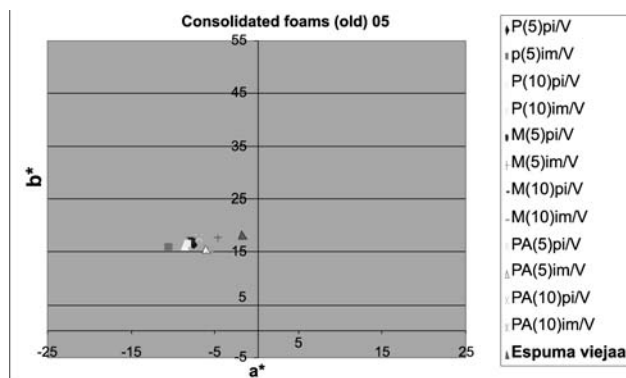


Figure 5. Chromaticity diagram showing a comparison between the old foam reference and the old foam consolidated samples.

In general, the change observed in the set of samples treated with consolidant can be considered small. After inspecting the results, there were no significant differences in terms of the concentration of consolidant (5-10%) or the method of application (brush, br or impregnation, im).

1.2. Differences in brightness, tone and chroma ($\Delta L^*$, $\Delta C^*$, $\Delta h^o$):

A) New foams:
*Brightness:* $\Delta L^* \rightarrow$ **-2 to 5**
The majority of the samples show some brightening ($\Delta L^* \rightarrow$ 0 to 5'1). Only two samples treated with MOWILITH showed some slight darkening ($\Delta L^* \rightarrow$ -1 to -1'7).

*Chroma*: $\Delta C^* \rightarrow$ **-2 to 6'2**
Test specimens consolidated with MOWILITH and PLEXTOL experienced a slight increase: ($\Delta C^* \rightarrow$ 1'6 to 3'5) and ($\Delta C^* \rightarrow$ 1'8 to 6'2), respectively. The opposite effect was observed in specimens treated with PARALOID ($\Delta C^* \rightarrow$ -0'7 to -1'9)

*Tone*: $\Delta h^o \rightarrow$ **4'6 to 21**
Test specimens treated with PARALOID experienced less variations in tone ($\Delta h^o \rightarrow$ 4'6 to 8'7) followed by those consolidated using MOWILITH and PLEXTOL for which the following values were obtained: ($\Delta h^o \rightarrow$ 8'1 to 19) and ($\Delta h^o \rightarrow$ 11'6 to 21) respectively.

These values indicate that the samples shifted toward green. This effect was especially observed in samples treated with PLEXTOL followed by samples that had been consolidated using MOWILITH.

B) Old foams:
*Brightness:* $\Delta L^* \rightarrow$ **-1'3 to 5'3**
The majority of the samples became slightly brighter ($\Delta L^* \rightarrow$ 0 to 5'3). This effect is similar to the one observed in new foams. Only two samples exhibited slight darkening ($\Delta L^* \rightarrow$ -0'5 to-1'3)

*Chroma*: $\Delta C^* \rightarrow$ **-2 to 1'3**
These foams hardly changed in terms of their chroma after consolidation. This was also observed in the new foams, in other words,

samples treated with PARALOID showed a smaller change ($\Delta C^* \rightarrow$ 0 to -1'9), while those treated with MOWILITH and PLEXTOL exhibited a slight increase: ($\Delta C^* \rightarrow$ 0'2 to 1'3) and ($\Delta C^* \rightarrow$ 0'2 to 0'8) for MOWILITH and PLEXTOL, respectively.

*Tone*: $\Delta h^o \rightarrow$ **9'5 to 28**
A slight shift towards the green edge was observed in all samples ($\Delta h^o \rightarrow$ 9'5 to 28). The sample showing the least amount of change is the one that was impregnated with a 5% MOWILITH solution while the one impregnated with a 5% PLEXTOL solution presented greater change. The remaining specimens changed in equal amounts ($\Delta h^o \rightarrow$ 14 to 21°).

**2. Chromatic variation observed in consolidated samples after exposure to UV-light for a 3600 hour period.**

2.1. Total Colour Difference ($\Delta E^*$):

A) New foams:
Total colour differences ($\Delta E^*$) were observed in the following range: **47 to 49.2**. It can be said that all test specimens experienced similar changes, in other words, no one consolidant that is better than the others.

B) Old foams:
Total colour difference values ($\Delta E^*$) range from **30 to 35,** in other words they undergo smaller changes than new foams.

In samples prepared with old foams, we can infer that, even to a lesser extent, test specimens consolidated with PARALOID undergo smaller changes **($\Delta E^* \rightarrow$30 to 32).** This can be inferred after observing the results obtained for samples consolidated with PLEXTOL **($\Delta E^* \rightarrow$ 30 to 35)** and MOWILITH **($\Delta E^* \rightarrow$ 33 to 35).**

Generally, the change experienced by the set of test specimens after UV-light radiation can be considered to be of a greater magnitude. The results did not show significant differences based on the concentration of the consolidant (5-10%) or its method of application (brush or impregnation).
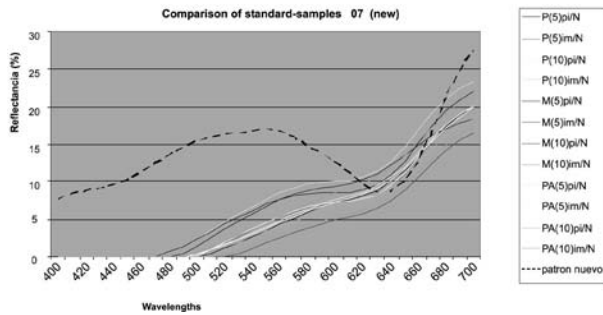
Figure 6. Reflectance curves of the new foam reference sample along with those obtained for consolidated samples after UV-light accelerated ageing (3600 h)
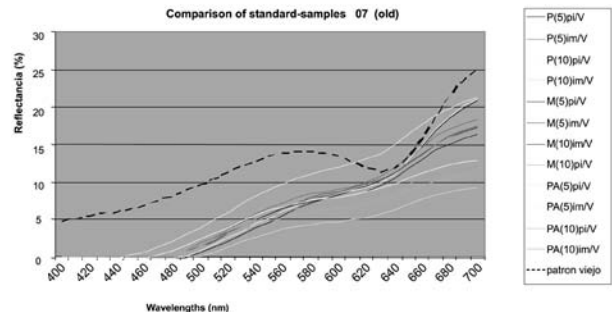


Figure 7. Reflectance curves of the old foam reference sample along with those obtained for consolidated samples after UV-light accelerated ageing (3600 h).

2.2. Differences in brightness, tone and chroma (ΔL*, ΔC*, Δhº):

A) New foams:
**Brightness:**          ΔL*→ **-13 to -23**
In other words, all samples became less bright.
 PLEXTOL (ΔL*→ -13 to –20'4).
 PARALOID (ΔL*→ -19 to –23).
 MOWILITH (ΔL*→ -18 to –28).

**Chroma**: ΔC*→ **21 to 36'5**
The chroma increases for all samples.
MOWILITH (ΔC*→ 21 to 32) samples exhibiting minor changes
PARALOID (ΔC*→ 26'4 to 32).
PLEXTOL (ΔC*→ 29 to 36'5) samples exhibiting greater changes

**Tone**: Δhº→ **-59'3 to -87º**
**All samples** show a considerable oscillation towards orange.
PLEXTOL (Δhº→ -59'3 to –70) samples exhibiting minor changes
PARALOID (Δhº→ -72 to –75'5).
MOWILITH (Δhº→ -67 to –87) samples exhibiting greater changes

B) Old foams:
**Brightness**: ΔL*→ **-6'4** [PA(5)br] to **–22** [P(10)im]
A similar effect to the one produced in the new foams was observed. In other words, the samples darkened to a lesser extent.

 PARALOID (ΔL*→ -6 to –16'5).
 MOWILITH (ΔL*→ -13 to –14).
 PLEXTOL (ΔL*→ -11 to –22).

**Chroma**: ΔC*→ **17'5** [P(10)im] **to 32**[P(10)br]
Considerable increase. Samples exhibit similar changes (increase of approximately 30 units) except test specimens that were impregnated with a 10% PLEXTOL solution, for which a 17 unit change was observed.

PARALOID (ΔC*→ 24 to 31).
MOWILITH (ΔC*→ 29 to 30'5).
PLEXTOL (ΔC*→ 17'5 to 32).

**Tone**: Δhº→ **-14** [PA(5)pi]–**25'4** [P(10)im]
These test specimens experienced a smaller change in tone than the ones made out of new foam. Samples yellowed substantially and became less red than the majority of the ones prepared using new foams.

PARALOID (ΔC*→ -14 to -17).
MOWILITH (ΔC*→ -18 to -20).
PLEXTOL (ΔC*→ -16 to -25'4).

CONCLUSION 1 Chromatic variation observed in the samples after the application of different consolidants.

**TEST SPECIMENS OF PHENOLIC FOAM**

**Operator:** Marisa Martínez Bazán
**Meter:** Minolta CM-2600d Spectrophotometer (2)

| **COND. 4** (M/I/100 | Illuminant D65 Standard observer 10º SCI 100% UV Area M | | |
|---|---|---|---|

| | | | |
|---|---|---|---|
| **Standard N** | | | |
| **Standard V** | | | |

| L* | a* | b* | C* | h |
|---|---|---|---|---|
| 45 | -11.9 | 10.2 | 15.7 | 139.5 |
| 41.5 | -1.8 | 18.1 | 18.2 | 95.6 |

| | **2005 (consolidated samples)** | | | | | **Dif standard-consolidated samples (05)** | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Name** | **L*** | **a*** | **b*** | **C*** | **h** | **ΔL*** | **Δa*** | **Δb*** | **ΔC*** | **Δh** | **ΔE** |
| P(5)pi/N | 49.6 | -15.3 | 8.5 | 17.5 | 151.1 | 4.3 | -3.4 | -1.7 | 1.8 | 11.6 | **5.8** |
| P(5)im/N | 45.1 | -20.4 | 7.2 | 21.6 | 160.6 | -0.1 | -8.4 | -3.0 | 5.9 | 21.0 | **8.9** |
| P(10)pi/N | 46.4 | -20.1 | 8.7 | 21.9 | 156.5 | 1.2 | -8.1 | -1.5 | 6.2 | 17.0 | **8.3** |
| P(10)im/N | 50.3 | -19.5 | 7.5 | 20.8 | 159.0 | 5.1 | -7.5 | -2.7 | 5.1 | 19.5 | **9.5** |
| M(5)pi/N | 43.5 | -16.7 | 7.9 | 18.5 | 154.6 | -1.7 | -4.7 | -2.3 | 2.7 | 15.1 | **5.5** |
| M(5)im/N | 44.3 | -14.6 | 9.3 | 17.3 | 147.6 | -0.9 | -2.7 | -0.9 | 1.6 | 8.1 | **3.0** |
| M(10)pi/N | 49.7 | -17.9 | 7.0 | 19.3 | 158.6 | 4.5 | -6.0 | -3.2 | 3.5 | 19.0 | **8.1** |
| M(10)im/N | 47.9 | -17.4 | 7.6 | 19.0 | 156.2 | 2.6 | -5.4 | -2.6 | 3.3 | 16.7 | **6.5** |
| PA(5)pi/N | 49.3 | -11.2 | 8.1 | 13.8 | 144.2 | 4.1 | 0.8 | -2.1 | -1.9 | 4.6 | **4.7** |
| PA(5)im/N | 50.0 | -12.6. | 8.2 | 15.0 | 146.9 | 4.8 | -0.6 | -2.0 | -0.7 | 7.4 | **5.2** |
| PA(10)pi/N | 45.3 | -12.7 | 7.9 | 14.9 | 148.2 | 0.0 | -0.7 | -2.3 | -0.8 | 8.7 | **2.4** |
| PA(10)im/N | 50.3 | -12.0 | 8.4 | 14.6 | 145.0 | 5.0 | 0.0 | -1.8 | -1.1 | 5.5 | **5.3** |
| **Name** | **L*** | **a*** | **b*** | **C*** | **h** | **ΔL*** | **Δa*** | **Δb*** | **ΔC*** | **Δh** | **ΔE** |
| | **2005 (consolidated samples)** | | | | | **Dif standard-consolidated samples (05)** | | | | | |
| P(5)pi/V | 44.5 | -7.6 | 16.4 | 18.1 | 114.9 | 3.0 | -5.8 | -1.7 | -0.1 | 19.2 | **6.7** |
| P(5)im/V | 44.2 | -10.5 | 15.8 | 19.0 | 123.5 | 2.6 | -8.7 | -2.2 | 0.8 | 27.9 | **9.4** |
| P(10)pi/V | 43.7 | -8.6 | 16.2 | 18.3 | 117.9 | 2.2 | -6.8 | -1.9 | 0.2 | 22.3 | **7.4** |
| P(10)im/V | 40.2 | -6.9 | 17.6 | 18.9 | 111.4 | -1.3 | -5.1 | -0.5 | 0.8 | 15.7 | **5.3** |
| M(5)pi/V | 41.0 | -7.6 | 17.1 | 18.7 | 114.1 | -0.5 | -5.9 | -1.0 | 0.6 | 18.4 | **6.0** |
| M(5)im/V | 43.5 | -4.8 | 17.7 | 18.3 | 105.1 | 1.9 | -3.0 | -0.4 | 0.1 | 9.5 | **3.6** |
| M(10)im/V | 41.6 | -7.0 | 18.0 | 19.3 | 111.2 | 0.0 | -5.2 | -0.1 | 1.1 | 15.6 | **5.2** |
| M(10)im/V | 42.5 | -8.4 | 17.6 | 19.5 | 115.6 | 1.0 | -6.6 | -0.5 | 1.3 | 19.9 | **6.7** |
| PA(5)pi/V | 46.8 | -8.2 | 16.4 | 18.4 | 116.6 | 5.3 | -6.4 | -1.6 | 0.2 | 21.0 | **8.5** |
| PA(5)im/V | 44.1 | -6.1 | 15.6 | 16.8 | 111.3 | 2.6 | -4.3 | -2.5 | -1.4 | 15.7 | **5.6** |
| PA(10)pi/V | 44.0 | -5.7 | 15.5 | 16.6 | 110.2 | 2.5 | -3.9 | -2.6 | -1.6 | 14.6 | **5.3** |
| PA(10)im/V | 48.7 | -5.4 | 15.4 | 16.3 | 109.4 | 7.1 | -3.6 | -2.7 | -1.9 | 13.8 | **8.5** |

Table 2. Variation of the chromatic coordinates L*, a*, b*, total colour variation (ΔE*), chroma variation (ΔC*) and tone variation (Δhº) of original phenolic resin samples (old) and of new foams after the application of different consolidants
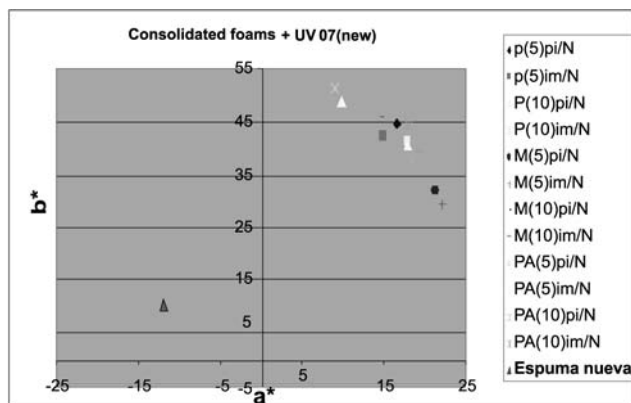
Figure 8. Chromaticity diagram comparing the new foam reference with the consolidated samples after UV-light accelerated ageing (3600 h).
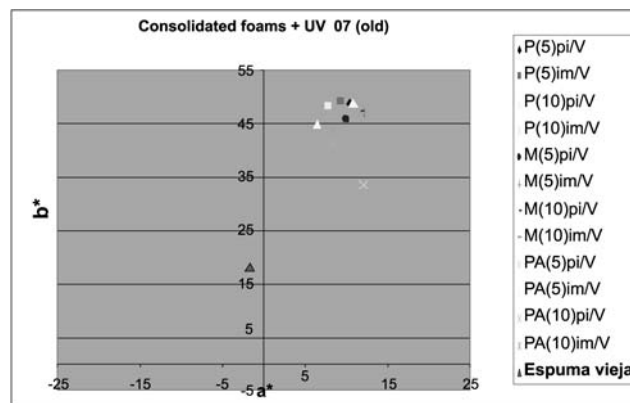


Figure 9. Chromaticity diagram comparing the old foam reference with the consolidated samples after UV-light accelerated ageing (3600 h).

### Total Colour Difference:

A)PARALOID is the consolidant that has produced the least amount of chromatic changes ($\Delta E^*$= 2 to 5), while the results for PLEXTOL were poorer ($\Delta E^*$= 6 to 10).

B) For the old foams, MOWILITH produced better results ($\Delta E^*$= 4 to 7), while PLEXTOL continues to be the worst material ($\Delta E^*$= 5 to 9)

### Brightness:

A) In general, samples became a little brighter ($\Delta L^*$= 0 to 6), except those with lower MOWILITH concentrations for which a slight darkening was observed ($\Delta L^*$= -1 to -2)

B) Commonly, the old foams became a little brighter ($\Delta L^*$= 0 to 5), except in one case with MOWILITH and another in which PLEXTOL was used. In these two cases, the samples have slightly darken ($\Delta L^*$= -0.5 to -2)

### Chroma:

A) Samples treated with MOWILITH and PLEXTOL underwent a slight increase in chroma: ($\Delta C^* \rightarrow$ 1'6 to 3'5) and ($\Delta C^* \rightarrow$ 1'8 to

6'2) respectively. The opposite was observed in samples treated with PARALOID ($\Delta C^* \rightarrow$ -0'7 to -1'9)

B) Old foams hardly experienced any changes in chroma after consolidation. The same effect is observed in samples made out of new foams. In other words the ones treated with PARALOID show a decrease in chroma ($\Delta C^* \rightarrow$ -0'2 to -1'9), while those treated with MOWILITH and PLEXTOL exhibit a slight increase: ($\Delta C^* \rightarrow$ 0'2 to 1'3) y ($\Delta C^* \rightarrow$ 0'2 to 0'8), respectively.

### Tone:

A) The samples exhibited a small change towards green, especially the ones treated with PLEXTOL, followed by those that were consolidated with MOWILITH. Samples treated with PARALOID showed lesser changes in tone.

B) A higher change in tone than that observed in the new foams. The old foam samples are more yellow than the new ones. 30 and a 10 degree shifts towards green were observed in the least favourable case (5% PLEXTOL) and the most favourable case (5% MOWILITH), respectively.

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**TEST SPECIMENS OF PHENOLIC FOAM**

**Operator:** Marisa Martínez Bazán
**Meter:** Minolta CM-2600d Spectrophotometer (2)

| | | | |
|---|---|---|---|
| **COND. 4** | Illuminant D65 | | |
| (M/I/100 | Standard observer 10º | | |
| | SCI | | |
| | 100% UV | **Standard N** | |
| | Area M | **Standard V** | |

| | L* | a* | b* | C* | h |
|---|---|---|---|---|---|
| Standard N | 45 | -11.9 | 10.2 | 15.7 | 139.5 |
| Standard V | 41.5 | -1.8 | 18.1 | 18.2 | 95.6 |

| 2007 (consolidated samples +UV) | | | | | | Dif standard-consolidated samples +UV (07) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Name** | **L*** | **a*** | **b*** | **C*** | **h** | **ΔL*** | **Δa*** | **Δb*** | **ΔC*** | **Δh** | **ΔE** |
| P(5)pi/N | 26.3 | 16.4 | 44.5 | 47.4 | 69.8 | -18.9 | 28.3 | 34.3 | 31.7 | -69.7 | 48.3 |
| P(5)im/N | 24.9 | 14.9 | 42.2 | 44.8 | 70.6 | -20.4 | 26.8 | 32.0 | 29.1 | -68.9 | 46.5 |
| P(10)pi/N | 29.3 | 9.7 | 48.8 | 49.7 | 78.8 | -15.9 | 21.6 | 38.6 | 34.0 | -60.7 | 47.0 |
| P(10)im/N | 32.0 | 8.8 | 51.5 | 52.2 | 80.3 | -13.3 | 20.8 | 41.3 | 36.5 | -59.3 | 48.1 |
| M(5)pi/N | 18.6 | 21.2 | 31.8 | 38.2 | 56.3 | -26.6 | 33.1 | 21.6 | 22.5 | -83.2 | 47.7 |
| M(5)im/N | 17.1 | 22.1 | 29.2 | 36.7 | 52.9 | -28.2 | 34.1 | 19.0 | 21.0 | -86.6 | 48.1 |
| M(10)pi/N | 27.2 | 14.4 | 45.8 | 48.0 | 72.5 | -18.0 | 26.4 | 35.6 | 32.3 | -67.0 | 47.8 |
| M(10)im/N | 23.1 | 19.1 | 39.4 | 43.8 | 64.1 | -22.2 | 31.1 | 29.2 | 28.0 | -75.4 | 48.0 |
| PA(5)pi/N | 24.4 | 17.8 | 41.5 | 45.1 | 66.8 | -20.8 | 29.7 | 31.3 | 29.4 | -72.7 | 47.9 |
| PA(5)im/N | 23.9 | 17.7 | 40.6 | 44.3 | 66.5 | -21.3 | 29.6 | 30.4 | 28.6 | -73.0 | 47.5 |
| PA(10)pi/N | 22.2 | 18.4 | 37.9 | 42.1 | 64.0 | -23.0 | 30.4 | 27.7 | 26.4 | -75.5 | 47.1 |
| PA(10)im/N | 26.1 | 18.0 | 44.2 | 47.7 | 67.9 | -19.1 | 29.9 | 34.0 | 32.0 | -71.6 | 49.2 |

| 2007 (consolidated samples +UV) | | | | | | Dif standard-consolidated samples +UV (07) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Name** | **L*** | **a*** | **b*** | **C*** | **h** | **ΔL*** | **Δa*** | **Δb*** | **ΔC*** | **Δh** | **ΔE** |
| P(5)pi/V | 29.7 | 10.5 | 48.7 | 49.9 | 77.8 | -11.8 | 12.3 | 30.6 | 31.7 | -17.8 | 35.1 |
| P(5)im/V | 30.7 | 9.3 | 49.4 | 50.2 | 79.3 | -10.9 | 11.1 | 31.3 | 32.0 | -16.3 | 34.9 |
| P(10)pi/V | 29.9 | 10.8 | 48.9 | 50.1 | 77.5 | -11.6 | 12.6 | 30.8 | 31.9 | -18.1 | 35.2 |
| P(10)im/V | 19.7 | 12.1 | 33.6 | 35.7 | 70.2 | -21.8 | 13.8 | 15.5 | 17.5 | -25.4 | 30.1 |
| M(5)pi/V | 27.8 | 10.0 | 45.8 | 46.8 | 77.6 | -13.7 | 11.8 | 27.7 | 28.7 | -18.0 | 33.1 |
| M(5)im/V | 28.5 | 12.0 | 47.0 | 48.6 | 75.7 | -13.0 | 13.8 | 29.0 | 30.4 | -19.9 | 34.6 |
| M(10)pi/V | 28.2 | 12.0 | 46.9 | 48.4 | 75.7 | -13.3 | 13.8 | 28.8 | 30.2 | -19.9 | 34.6 |
| M(10)pi/V | 28.4 | 11.7 | 47.2 | 48.6 | 76.1 | -13.1 | 13.5 | 29.1 | 30.5 | -19.5 | 34.6 |
| PA(5)pi/V | 35.1 | 7.7 | 48.3 | 48.9 | 80.9 | -6.4 | 9.5 | 30.2 | 30.7 | -14.7 | 32.3 |
| PA(5)im/V | 28.7 | 6.5 | 45.1 | 45.5 | 81.8 | -12.8 | 8.3 | 27.0 | 27.3 | -13.8 | 31.0 |
| PA(10)pi/V | 25.0 | 8.5 | 41.5 | 42.3 | 78.4 | -16.5 | 10.3 | 23.4 | 24.1 | -17.2 | 30.4 |
| PA(10)im/V | 26.7 | 8.3 | 43.9 | 44.7 | 79.4 | -14.8 | 10.0 | 25.8 | 26.5 | -16.3 | 31.4 |

Table 3. Variation of the chromatic coordinates L*, a*, b*, total colour variation ($\Delta E^*$), chroma variation ($\Delta C^*$) and tone variation ($\Delta h^o$) of original phenolic resin samples (old) and of new foams after UV-light accelerated ageing (3600 h)

CONCLUSION 2 Chromatic variation observed in the consolidated samples after exposure to 3.600 hours of UV-light radiation.

### Total Colour Difference:

The change observed in the set of samples with consolidants after exposure to UV-light radiation is considered to be large. There are no discernible differences between consolidants and even less changes were observed when evaluating both the concentration and the method of application (paint brush or impregnation).

The new foams show greater changes than the old ones. The differences in ΔE* are 47-49 and 30-35 for new and old foams, respectively.

### Brightness:

A) All samples became less bright  $\Delta L^* \rightarrow$ **-13 to -23**
B) Old foams also became less bright. However, the change was to a lesser extent than that observed in the new ones. $\Delta L^* \rightarrow$ **-6'4 to –22**

### Chroma:

A) The chroma increased for all samples $\Delta C^* \rightarrow$ **21 to 36'5**

B) There is a considerable increase in the old foams. They all exhibit similar changes (increase of approximately 30 units) except for the lab specimens that were impregnated with Plextol (10%) which only exhibit a 17 unit change. $\Delta C^* \rightarrow$ **17'5 to 32**

### Tone:

A) All new foams exhibit a considerable oscillation towards orange. $\Delta h^\circ \rightarrow$ **-59'3 to -87º**

B) The change in tone is less than that observed in samples made out of new foam. Samples tend to yellow substantially or become less red than many of the new ones. $\Delta h^\circ \rightarrow$ **-14 to –25'4**

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## NOTES

[1] For additional information, see Areizaga *et al.*, 2002, p.371.

[2] Phenolic resins may be classified into two types: novalac and resol, the resol type being the more commonly found in foams because of their ease of synthesis. Acidic and basic catalytic agents are employed for novalac and resol respectively (Gnauck and Fründt P, 1991. p.169).

[3] For additional information, see Mas i Barberà *et al., 2005, p. 417.*

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*Versión española*

TITULO: *Estudio por espectrofotometría visible de la idoneidad en la aplicación de consolidantes orgánicos a una escultura de arte contemporáneo*

RESUMEN: *El presente trabajo es la continuación del estudio llevado a cabo para determinar la idoneidad de una serie de consolidantes susceptibles de ser empleados en el proceso conservativo-preventivo de una pieza escultórica de arte contemporáneo. La pieza en cuestión, es una escultura tallada en espuma fenólica con una serie de particularidades que la deparan como única e irrepetible.*
*En esta ocasión se analizan los datos espectrales obtenidos al medir el material que conforma la escultura tras ser tratado con varios consolidantes orgánicos, a diferentes concentraciones y modos de aplicación, así como después de someterse a un ensayo de envejecimiento acelerado por irradiación con luz ultravioleta durante un período de 3600 horas de exposición.*
*Se ha elegido la espectrofotometría visible por ser un método de análisis no destructivo de gran utilidad para valorar cuantitativamente, mediante ensayos de laboratorio, cuales son los materiales más idóneos a emplear en los distintos procesos de restauración (en cuanto a la variación de color introducida  con su aplicación o, en cuanto a la previsión de su resistencia cromática con el paso del tiempo)*

PALABRAS CLAVES: *espuma fenólica, espectrofotometría visible, métodos preventivos, consolidación, Arte Contemporáneo*