



## **Volumetric and chromatic reintegration in conservation of *in situ* glazed tiles**

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### **SUMMARY:**

*Volumetric and chromatic reintegration is one of the most important but challenging treatments in conservation of *in situ* glazed tiles due to the need to protect them from water intrusion and further deterioration despite the demanding conditions and requirements needed in outdoor exposure.*

*A set of six infill pastes based on aerial lime, hydraulic lime, aerial lime plus vinylic resin, epoxy resin and polyester resin binders was selected based on materials applied in previously reported interventions and the experience of professionals working in the field. The laboratory studies included the characterization of the infill pastes with and without chromatic reintegration/coating layer (SEM, MIP, porosity, water absorption, water vapour permeability, adhesion to the ceramic) and their behaviour after cure, artificial ageing (salt ageing, UV-Temp-RH cycles) and natural ageing. The results obtained allowed to formulate some considerations about these materials, their different characteristics and their performance when applied in the infill of architectural tile lacunae. The laboratory results have been compared with the performance of similar treatments surveyed on sites where they had been applied.*

**KEY-WORDS:** *chromatic reintegration; *in situ* conservation treatment; filling materials; lacunae in azulejos; volumetric reintegration*



## INTRODUCTION

An extensive variety of materials have been used as infill pastes to treat azulejo glaze lacunae, sometimes in an empirical way and without much knowledge of their characteristics such as compatibility, reversibility or durability. Frequent poor performance of the current treatments is observable *in situ* namely: disaggregation, detachment, colour changes and also high bioreceptivity of the filling materials or of the chromatic reintegration layer.

The infill patches are usually constituted of a multiple layer system, which includes (in addition to the interaction with the ceramic body), one layer as substrate repair, one layer of chromatic reintegration and a final protection coating. Therefore, when studying the infill of tile lacunae it is also necessary to have in consideration the impact of these two last layers in the performance of the whole system. Sustained on the information previously collected during this project, various types of finishing layers were applied on an aerial lime based infill paste and their characteristics were also studied. The understanding of the effectiveness, compatibility and ageing behaviour of applied solutions (materials and procedures), vital aspects to optimize and develop better treatments for future interventions, were a major concern of the present project.

## METHODS

Six different formulations of fillers were used [all compositions expressed as v:v ratios, (except iv)]: i) 1:3 aerial lime (*Calcidrata*<sup>®</sup> Lime Putty): Silica powder; ii) 1:3:0.1 aerial lime (*Calcidrata*<sup>®</sup> Lime Putty): silica powder: vinylic resin (*Vinnapas*<sup>®</sup> 8031H); iii) 1:3 hydraulic lime (*Crualy Lafarge*<sup>®</sup> (*NHL 2*)): silica powder; iv) 1:9 (m:m) epoxy resin (*Icosit*<sup>®</sup> K101): lime stone powder; v) two component polyester paste (*Airocoll*<sup>®</sup> S) vi) two component zinc hydroxychloride paste (*Lithos arte*<sup>®</sup>). This selection was based on a review on the materials currently used and on the information gathered in an international survey [1].

The properties of the different combinations (Figure 1) after cure were determined by means of: SEM, hydrostatic weighing, mercury intrusion porosimetry, water absorption by capillarity, water vapour permeability, flexural and pull-off strengths as well as water and thermal expansibilities. After natural (one year outdoor exposure) and artificial (NaCl salt ageing, UV-Temp-RH cycles -30°C with condensed water and 4h with 60°C and ultraviolet radiation and immersion in water every 168h up to 1000h of ultraviolet radiation) ageing, the samples were analysed and the differences registered. The ones submitted to artificial ageing were also tested to pull-off strength.

Ten different solutions of finishing layers applied on single substrate made of aerial lime plus silica powder (1:3) were studied: acrylic paint (ultramarine blue *Winsor&Newton Galeria*<sup>®</sup>); acrylic paint plus acrylic resin (20% *Paraloid*<sup>®</sup> B72 in acetone); acrylic resin (20% *Paraloid*<sup>®</sup> B72 in acetone); acrylic resin (20% *Paraloid*<sup>®</sup> B44 in acetone); acrylic emulsion (*Primal*<sup>®</sup> ac33); microcrystalline wax (*Renaissance*<sup>®</sup>); epoxy resin (*Hxtal nyl-1*<sup>®</sup>); silane-siloxane (*Silres*<sup>®</sup> 290); ethyl silicate (*Tegovakon*<sup>®</sup> V); and a polyurethane varnish (*Bayhydur*<sup>®</sup> xp 2547+*Bayhydrol*<sup>®</sup>). Their properties have been determined by colorimetry, hydrostatic weighing and water absorption by capillarity, before and after artificial ageing (salt ageing, UV-Temp-RH cycles).



Figure 1. Samples prepared to be characterized after cure.

## SYNOPSIS OF THE RESULTS

The properties of the organic filler pastes have very different characteristics from the inorganic ones. Also they show higher bending and pull-off strengths and water or thermal expansibilities when compared with those measured in original tiles [2].

Polyester pastes behave poorly due to retraction upon cure. Epoxy pastes perform well in the ageing tests carried out.

The chromatic layer seems to favour the stability of the lacunae infills and most coatings were efficient in limiting water absorption, although Tegovakon V and Bilres290 did not reduce the water vapour permeability.

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## Bibliographic references

- 1 MENDES, M.T; Pereira, S; Ferreira, T; Mirão, J. & Candeias, A. - *In Situ Preservation and Restoration of Architectural Tiles, Materials and Procedures: Results of an International Survey*, International Journal of Conservation Science, 6, 2015, 51-62
- 2 PEREIRA, S; Mimoso, J.M. & Santos Silva, A. - *Physical-chemical characterization of historic Portuguese tiles*, Relatório LNEC 23/2011, Lisbon, LNEC, 2011