



## Influence of paints on drying and salt distribution processes in porous building materials

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### ABSTRACT

Paints are widely used as finishing coats on all kinds of buildings. Aiming at a better understanding of how paints influence salt decay processes, experiments were performed on painted and unpainted specimens: (a) crystallization tests on specimens composed of a plaster on brick substrate; (b) drying experiments on stone specimens, monitored by means of a two-dimensional magnetic resonance imaging technique. The results of these experiments suggest that: (i) paints tend to increase the presence of moisture and salt deposition on or close to the surface of walls; (ii) the salt-accumulation behaviour and related features of different plasters/renders may be differently affected by paint layers.

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### 1. Introduction

Old buildings are generally built of thick solid masonry walls of porous and very absorbent materials. These buildings are frequently affected by salt decay problems that require appropriate interventions to solve, or at least minimize, such problems. However, professionals involved in the conservation of old buildings claim that salt damage features are often worsened, rather than minimized, after restoration interventions, even when they were specifically carried out to solve salt decay problems [1]. This common statement refers essentially to an increase of surface damage (Fig. 1).

Crystallization tests carried out on specimens composed of a plaster applied on a brick substrate suggested that the use of paints may be one of the factors that can lead to an increase in surface damage by soluble salts. It was observed that the salt-accumulation behaviour of one of the plasters changed completely when a paint layer was applied. In the absence of paint, the salt crystallized within the plaster, thereby enabling a surface free of damage (salt-accumulating behaviour). However, when paint was present, the salt solution was able to reach the outer surface of the specimens and efflorescence was formed (salt-transporting behaviour).

Paints are widely used as finishing coats on all kinds of buildings, especially in the case of plastered and rendered walls. Painting of salt loaded walls is very often carried out within restoration interventions, for aesthetical purposes or to improve the health conditions of rooms. Hence, it is important to understand whether and how paints can promote the occurrence of surface damage by soluble salts. In addition to the obvious problems associated to an extension of the salt damaged area, this can represent a corruption of the fundamental working principle of salt-accumulating plasters. These are expensive products designed precisely to impede salt solutions from reaching the outer surface of walls. Furthermore, in historic buildings, extension of the salt damaged area may also enable salt crystallization in adjacent elements, such as ordinary stonework or even valuable paintings or sculptures.

In order to reach a better understanding of how paints influence salt decay processes, drying experiments were carried out on painted and unpainted specimens. Indeed, salt decay ordinarily occurs within drying processes, by which the concentration of the salt solutions increases and, hence, crystallization eventually takes place on the surface (efflorescence) or in the pores (subflorescence) of the materials.

The drying experiments were monitored by means of a magnetic resonance imaging (MRI) technique. This technique provides two-dimensional (2D) images that map the distribution of moisture in the specimens at chosen moments. The technique allows also obtaining one-dimensional (1D) profiles that express the moisture content over chosen cross-sections of the specimens.

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Fig. 1. Different types of surface damage due to salt crystallization: efflorescence (left), physical damage to materials (centre) and dampness (right).

This article presents the crystallization tests (Section 2) and MRI-monitored drying experiments (Section 3) carried out on painted and unpainted specimens. Based on the obtained results, the article then discusses, in Section 4, how paints may influence drying and salt deposition processes in porous building materials.

## 2. Salt crystallization tests

### 2.1. Aims and objectives

Salt crystallization tests were performed within the research project COMPASS in order to compare the performance of different plasters in distinct conditions [2,3]. This article uses the results of some of these tests, carried out at LNEC on painted and unpainted specimens with the objective of evaluating the influence that paints can have on salt distribution and damage patterns.

### 2.2. Materials and methods

The salt crystallization tests were performed on different plasters applied on the same type of substrate. The work presented in this article concerns the tests carried out with 1.9 molal (10%W) NaCl solution on industrial plasters MEP-SP<sup>®</sup> and Parlumière<sup>®</sup> and traditional plaster LN, as well as the tests carried out on MEP-SP plaster with 0.8 molal (10%W) Na<sub>2</sub>SO<sub>4</sub> solution.

MEP-SP and Parlumière are commercial plasters specific for avoiding the occurrence of surface damage on moist salt laden walls, that is, designed to work as salt-accumulating plasters. LN is a site-made plaster composed of an adhesion coat and a base coat with volumetric composition of, respectively, 1:1:6 and 1:3:12 (cement CEM IV/A: LUSICAL<sup>®</sup> dry-hydrated lime: sand from the Tagus River).

The plaster/substrate specimens have flat dimensions of 40 mm × 40 mm to 45 mm × 45 mm. MEP-SP and Parlumière plasters are composed of a single mortar coat with a thickness of 20 mm. LN plaster is composed of a 5 mm adherence coat and a 20 mm base coat.

The plasters were applied on red Dutch ceramic brick substrate with a thickness of 20 mm. At around two months of age the specimens were laterally sealed with an epoxy resin.

Unpainted specimens and specimens painted with FUNCOSIL<sup>®</sup> silicone emulsion paint were tested for each plaster and type of salt.

The COMPASS crystallization test [2] is based on cycles of contamination, by partial immersion of the specimens in the salt solution, and drying in a climatic chamber. Groups of, at least, two specimens were tested for each condition (kind of plaster, presence of paint and type of salt), as described in Table 1. The specimens were previously dried at 60 °C in a ventilated oven, allowed to cool at around 20 °C and 50% RH and then subjected to five wet–dry cycles according to the following procedure:

- The specimens are contaminated by partial immersion in the salt solution for 5 min, the liquid surface being around 5 mm above their bottom face. The 5 min period was chosen so that the wet front nearly reached the plaster/brick interface. Because only the brick substrate is contaminated, similar amounts of solution are introduced in every specimen (Table 1). This means that all the plasters will be subjected to an action of similar intensity, regardless of their suction properties.
- The specimens are subjected to daily cycles of 16 h at 40 °C and 20% RH plus 8 h at 20 °C and 50% RH. A climatic chamber with a low air velocity (a FITOCLIMA 500 EDTU<sup>®</sup> chamber by Aralab-Portugal) was used.
- Every week the specimens are weighed and their damage evaluated. A weighing device accurate to 0.001 g was used for the present tests.
- The wet/dry cycle ends when at least 80% of the water that the specimens contained immediately after being contaminated has evaporated. To prevent distortion of the results and because the drying behaviour of the specimens in each group was always very similar, it was decided that a cycle would end only when all the specimens of the group met this criterion. In fact, since the specimens were weighed only once a week, minimal shifts of the drying processes within each group might be magnified

Table 1  
Total amount of salt introduced in the specimens after 5 wet–dry cycles

Salt (g/m <sup>2</sup> )	MEP-SP <sup>®</sup> on brick		Parlumière <sup>®</sup> on brick		LN on brick	
	Unpainted	Silicone paint	Unpainted	Silicone paint	Unpainted	Silicone paint
NaCl	2416	2305	2373	2400	2249	2373
	2309	2256	2264	2295	2607	2386
	2356	2390	2275	2536	–	–
Na <sub>2</sub> SO <sub>4</sub>	2020	2091	–	–	–	–
	2343	2399	–	–	–	–

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