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Innovative method and apparatus for deep cleaning of soluble salts from mortars and lithic materials

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Abstract

A new method improves the quality and durability of decontamination by soluble salts, compared with conventional application of wraps. The salts inside the porous material are brought in solution by soaking with distilled water, then aspired by a suction nozzle applied to the sample surface, allowing the solution to move towards the surface. Finally, the method tested on plaster samples with different suction flows is effective in the cleaning. As every surface to be cleaned could be affected by different extent of deterioration, specific flows of suctions were investigated.

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Keywords: cleaning; soluble salts; porous materials; restoration; salt extraction.

1. Introduction

Inorganic porous materials such as plaster, mortar, concrete, brick and stones employed in monumental structures or in sculptures tend to develop saline efflorescence after their emplacement and during their life cycle [1]. The saline phases that represent some of the concurrent causes of mechanical and chemical deterioration in the host materials are mainly nitrates, carbonates and chlorides [2-9]. The presence of salt crystals on the surface and/or in

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the layers lying immediately under the wall surface can cause problems of preservation of works of art, as for example, fresco paintings, because salts are the main cause of formation of saline efflorescence or sub-efflorescence. Limiting the interaction between porous materials and salts is of primary importance dealing with cultural heritage, in fact artworks such as frescoes and sculptures can be affected by severe damages due to saline contamination.

Capillary rise [10] and damp circulation in masonry [11] are the main causes of salt mobilization and crystallization; their mobility and precipitation reflect cyclic wetting and evaporation, as demonstrated by the concentric aureoles or coronas characteristic of the alteration patterns. Thus, precipitation of progressively more soluble salts from brines suggests that water acts as a selective carrier. Due to stepwise water ingression and salt precipitation, the physical decay of the host material is progressive and infiltration to the core of the material is time, climate- and microtexture-dependent. For these reasons, the occurrence of salts inside the host can attain the deepest and the highest portions from the wetting source. The propagation of secondary porosity is consequent to the failed recovery of the host material.

Current procedures of desalination encompass several applications of cellulose or sepiolite wraps [12]. The procedure requires the application of poultice layer, soaked with distilled water, on the porous material, to be removed after the dry-out process. The process aims at breaking the surface tension of the saline solution (because of the short distance between the pack and the surface of the volume of porous material), thereby creating a so-called bridge that can accelerate the migration, by osmosis and/or capillarity, of the saline solution from the porous material to the pack. The water driving forces allows part of the soluble salts to move from the substrate to the poultice, where they result then trapped. This method however has a very slow dynamic, requiring a very long time for extracting all the saline solution from the volume of porous material. The cleaning takes place over many cycles of soaking and poultice substitution, corresponding to several days; moreover, should the saline solution not completely come out of the porous material, it might stagnate in the wall, thus causing further damage. So the salt removal fails to be shallow and not durable, as often the deeper crystals outcrop after a while.

Furthermore, the wraps and the poultices do not allow controlling whether all the saline solution has been extracted or is still impregnating the porous material.

Extracting a sample of porous material is not always possible or easy, e.g. because the removal of a part of a fresco painting is at any rate a destructive action. In addition, salts may be distributed unevenly in the porous material, that can be uneven itself.

This rationale led us to explore methods to achieve an effective cleaning and salt removal [13]. A new methodology and apparatus was patented by University of Genoa to improve the quality and the durability of decontamination from soluble salts, if compared with the conventional poultices of cellulose pulp and sepiolite. The cellulose pulp is a material used for the production of paper, also employed in the stages of restoration for efflorescence cleaning. Sepiolite is a clay mineral; the two are characterized by high surface/volume and hygroscopic behavior. Our method couples a mechanical treatment (suction) with dilution of salts and refining with wraps.

2. Experimental procedure

2.1. Material

Given the construction materials and techniques used in the past [14], we addressed the main building components, as plaster and stones. In particular, a preliminary experiment was carried out on plaster, which was characterized to describe its main properties. This material has always been used as a cover for masonry walls, therefore affected by the capillary rise in the wall structures and by their same damages [15].

The samples were made in laboratory using a mixture of Po river sand (60% in weight) and slaked lime (40% in weight). The mortar so prepared was poured into circular molds (Ø: 7 cm, thickness: 15 mm) to obtain homogeneous and reproducible specimens.