SLOVENSKI STANDARD
oSIST prEN 17891:2022

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Ohranjanje kulturne dediščine - Razsoljevanje poroznih anorganskih materialov z oblogami

Conservation of cultural heritage - Desalination of porous inorganic materials by poultices

Erhaltung des kulturellen Erbes - Entsalzung poröser anorganischer Materialien durch den Einsatz von Kompressen

Conservation du patrimoine culturel - Dessalement des matériaux inorganiques poreux par application de compresses

Ta slovenski standard je istoveten z: **prEN 17891**

ICS:

71.060.01	Anorganske kemikalije na splošno	Inorganic chemicals in general
97.195	Umetniški in obrtniški izdelki. Kulturne dobrine in kulturna dediščina	Items of art and handicrafts. Cultural property and heritage

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Conservation of cultural heritage - Desalination of porous inorganic materials by poultices

Conservation du patrimoine culturel - Dessalement des matériaux inorganiques poreux par application de compresses

Erhaltung des kulturellen Erbes - Entsalzung poröser anorganischer Materialien durch den Einsatz von Kompressen

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EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

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European foreword

This document (prEN 17891:2022) has been prepared by Technical Committee CEN/TC 346 “Conservation of Cultural Heritage”, the secretariat of which is held by UNI.

This document is currently submitted to the CEN Enquiry.

Introduction

Salts often present in stones and other porous inorganic building material as agents of decay of chemical, biological or anthropogenic origin. They can originate from surface deposition of atmospheric pollutants, from capillary transport or from external sources such as wind driven marine aerosol and from the material itself, and may be present due to previous, unsuitable, restoration interventions.

The salts most encountered in building materials are sulfates, chlorides, nitrates and carbonates of the cations sodium, potassium, ammonium, calcium and magnesium. Frequently present are the sulfates: gypsum ($CaSO_4 \cdot 2H_2O$), mirabilite ($Na_2SO_4 \cdot 10H_2O$) and thenardite (Na_2SO_4), epsomite ($MgSO_4 \cdot 7H_2O$) and other hydrates, the chlorides halite (NaCl) and sylvite (KCl), the nitrates niter (KNO_3) and nitratine ($NaNO_3$). and the carbonates thermonatrite ($Na_2CO_3 \cdot H_2O$), trona ($Na_3H(CO_3)_2 \cdot 2H_2O$. Less frequently double salts can be observed e.g. aphthitalite ($K_3Na(SO_4)_2$), carnallite ($KMgCl_3 \cdot 6H_2O$). Minor occurrence of phosphates and nitrites can be found.

In general, several types of soluble salts coexist and the ionic species present, depending on the conditions, can interact with each other to form complex salts or lead to crystallization phenomena within and/or on the substrate of the object.

Salts can damage the fabric of porous inorganic materials and lead to different decay morphologies sometimes causing substantial loss of material from the object. In addition, water-soluble salts have an influence on conservation measures such as cleaning, consolidation, treatment with hydrophobic materials and painting or plastering, often hindering them. The extent of deterioration and its appearance depend, for a given material, on the type of salt(s) crystallizing, the amount of salt(s) present, and the environmental conditions, as well as the presence of moisture, leading to crystallization cycles.

Reduction of the salt content (desalination) is an essential prerequisite for reducing the deterioration rate of the object and for the success and durability of a conservation measure. However, it is also recognized that in some systems desalination may at best be only partially successful.

Desalination by poultices is one of the most common methods used to reduce salt content from objects.

The term desalination is used to indicate a reduction in the ion content of water-soluble salts rather than a removal of all salts from the substrate at depth.

Before any intervention/application to reduce salts and their ensuing damage, it is advisable to consider investigation and relevant interventions to prevent moisture penetration as part of a holistic conservation approach.

Desalination is a decision that should be taken only after having adopted investigative measures which take into account all the aspects related to damage by salts, such as the type of salts present, their origin, their amount, distribution and location, as well as the surrounding environmental conditions. Information on previous treatments is also necessary.

In an indoor environment, to prevent the occurrence of salt dissolution-crystallization cycles due to relative humidity changes, it is recommended where possible to stabilize the interior climate [1].

When all possible interventions to prevent ongoing salt contamination have been considered and carried out, actions may be taken to reduce the quantity of salt(s) by a process of salt ion extraction also termed “desalination.”

NOTE To mitigate the presence of salts, apart from poultices, other actions such as the use of water baths, or sacrificial porous renders/plasters, or plant halophylous vegetation, or the application of sulphate reducing bacteria, or crystallization inhibitors, or electrochemical methods can also be proposed. These methods fall outside the scope of this document.

Based on the above consideration this document describes a procedure to reduce the amount of soluble salts/ions present in a porous inorganic material by a process of poultice desalination, outlining the requirements for the selection of poultice components and the procedure for application and monitoring the desalination.

Desalination by poultices refers to a removal of soluble salts, i.e. their ions, from the pore system of porous inorganic materials such as natural stones, bricks, terracotta, mortar, render/plaster and wall paintings. Treatments can be carried out *in situ*, or in a restoration workshop for movable objects.

Today a wide variety of poultices are available as single products and mixed with argillaceous materials (clay poultices, diatomaceous earth, bentonite, attapulgite, sepiolite) using rapid methods of application.

Desalination using poultices relies on the principle that salts dissolved in water are transported from the salt-contaminated porous materials into the poultice. The transport of salt solutions can take place both by ion diffusion and by movement of the fluid.

Very early on, the risk of removing the most soluble salts and leaving behind the less soluble ones (and risking greater ensuing damage) needs to be mentioned.

1 Scope

This document specifies one method for the desalination by poultices of porous inorganic materials constituting cultural heritage. The desalination methodology can be applied to salt-loaded porous inorganic materials either affected by salt weathering and/or to allow conservation treatments incompatible with soluble salt(s) contamination, or to prevent salt damage where contamination is known to be present. In all cases the desalination aims to decrease salt content.

Furthermore, this document gives the fundamental requirements for the desalination operation and guidelines for the choice of the most appropriate poultice components according to the characteristics of the substrate and types/quantities of salt(s) present in order to optimize the desalination process.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 15898, *Conservation of cultural heritage - Main general terms and definitions*

EN 16085, *Conservation of Cultural property - Methodology for sampling from materials of cultural property - General rules*

EN 16455, *Conservation of cultural heritage - Extraction and determination of soluble salts in natural stone and related materials used in and from cultural heritage*

EN 16682, *Conservation of cultural heritage - Methods of measurement of moisture content, or water content, in materials constituting immovable cultural heritage*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 15898 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at https://www.electropedia.org/
- ISO Online browsing platform: available at https://www.iso.org/obp

3.1
advection
transport of a substance (solute) or quantity by the bulk flux of the water

Note 1 to entry: It does not include transport of substances by molecular diffusion.

3.2
conductivity
measure of the ability of water to conduct an electrical current

Note 1 to entry: It is dependent on the amount and types of dissolved salts (or other compounds) in the water.

3.3
desalination
reduction of salt ion content in a material or substrate in order to decrease their concentration (to make them less harmful)

3.4
desalination poultices
appropriate water bearing materials applied on a porous inorganic material in order to reduce its soluble salt content

Note 1 to entry: Clay minerals, cellulose fibres, fine sand, gels etc. are usual compounds that are mixed in specific formulation with deionized water to make effective desalination poultices fitted to the substrate properties.

[SOURCE: EN 17138:2018, Annex A for the definition of compounds]

3.5
diffusion
process resulting from random motion of molecules by which there is a net flow of matter from a region of high concentration to a region of low concentration

3.6
moisture content
amount of water in the material, as determined in accordance with a gravimetric method specified in EN 16682

Note 1 to entry: The MC is expressed as a mass fraction in percent (%).

3.7
soluble salt
salt that readily dissolves in a solvent such as water in order to form a solution

Note 1 to entry: Within this document the term salt refers to soluble salts.

3.8
specific conductivity
conductivity of a solution measured between two electrodes 1 cm² in area and 1 cm distant

Note 1 to entry: The units are µS cm^{-1}

[SOURCE: EN 16455, 3.3]

4 Symbols and abbreviations

Y specific conductivity

IC ion conductivity in µS cm^{-1}

5 Principles of poultices desalination

5.1 General

Desalination by poultices refers to the removal of soluble salts, i.e. their ions, from the pore system of porous inorganic materials such as natural stones, bricks or terracotta, renders/plasters, or wall paintings.

In order to apply the desalination poultice it is first soaked with deionized water. After that, it is applied on the object (see Annex A).

The desalination process by poultice takes place into two steps:

In the first step the water penetrates into the porous material from the poultice and dissolves the soluble salts (Figure 1 b).

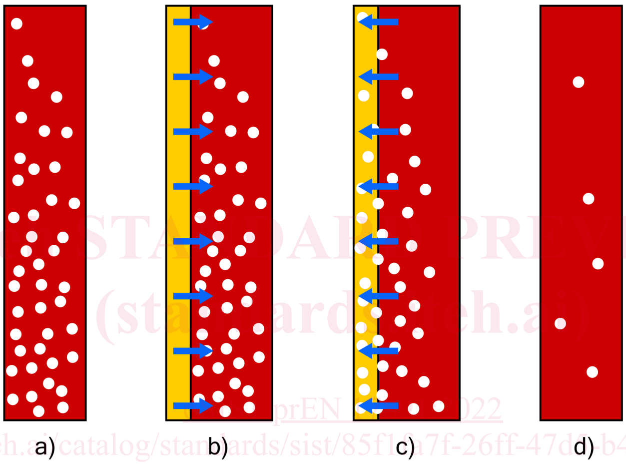
In the second step the “salt extraction” moves the dissolved ions from the substrate into the poultice (Figure 1 c).

Salt removal takes place in two different ways:

a) advection forces the transport of saline ions from the substrate to the poultice through capillary water flow which is a relatively quick process. This process is dependent on the pore size distribution of the poultice in relation to the substrate one;

b) diffusion process transports salt ions from the substrate into the poultice due to an unbalanced salt ion concentration gradient. This is generally a slower process with respect to advection. [2]

The concentration difference between the salt solution within the object (high concentration) and the water contained in the poultice (low concentration) generates an outward ion movement (diffusion).



Key

a substrate (in red) impregnated by salts

b poultice (in yellow) + substrate in the first phase

c poultice + substrate in the second phase

d substrate desalinated

Figure 1 — Desalination by poultices

The evaporation of water from the poultice to the surrounding air and the capillary transport (advection) from the substrate is another factor of salt migration.

In a porous material there will be always a balance between advection and diffusion.

Finally, if salt contaminated water can be driven properly into the poultice, and if the drying front is located within the poultice during the evaporation phase, salts may crystallize in the poultice [3].

5.2 Advection-based poulticing methods

The advection of water from a porous medium to another one can be described by the difference in pore-size distribution (and hence capillary pressure) between the two porous media. Dissolved ions of the salt(s) are transported by water flow during capillary suction.

During drying, the ions move towards the drying front by capillary flow (advection) and accumulate near the surface. Salts are advected from a medium with coarse pores substrate to a medium with fine pores, so the poultice should contain finer pores than the substrate pore sizes in order to ensure flow from the substrate to the poultice.

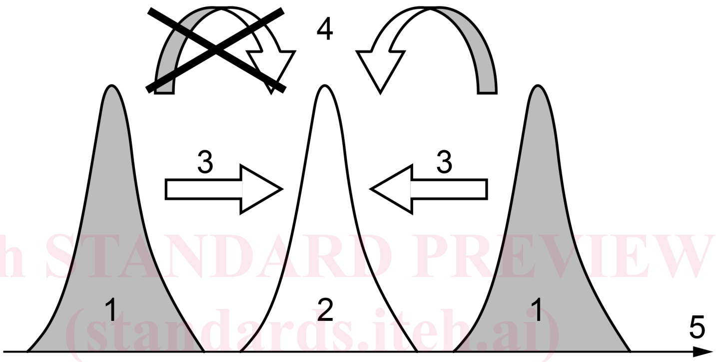
Advection is generally quicker than diffusion, and so desalination treatments based on advection are usually much faster.

The process of advection is described by the equation in Annex B [4].

5.3 Diffusion-based poulticing methods

The salt is transported through the water by diffusion due to the concentration gradient. For maximum extraction efficiency the salt content of the poultice, at the beginning of the process, should be as close to zero as possible. The process of diffusion can be described by a simple diffusion equation, which is also referred to as Fick's equation and successive modification (see Annex B).

Diffusion has the tendency to level off any accumulations, but in porous substrates it is a rather slow process.



Key

1 substrate

2 poultice

3 diffusion

4 advection

5 increasing pore size

Figure 2 — Schematic diagram illustrating the transport mechanisms (i.e. diffusion and advection) by which aqueous ions can travel from a substrate into a poultice, depending on the substrate pore size range relative to that (from Pel, Heritage and Voronina [5]).

6 Test equipment

a) ultra-pure water (specific conductivity ≤ 1 µS $\cdot$cm^{-1})

b) magnetic stirrer

c) conductivity meter capable of measuring to ≤ 1 µS$\cdot$cm^{-1}

d) instrument for the analysis of anions and cations