

NanoCStoneH – Innovative Nanocomposite for the Conservation and Consolidation of Carbonate Stone Heritage

Summary

The heritage built with carbonate stones with high cultural and economic importance all around the world is an important testimony of the past for present and future generations. Portugal has a wide cultural heritage in carbonate stones, some of them have already been listed as World Heritage by UNESCO, attracting visitants from everywhere. Centuries of exposure and the unavoidable environmental changes, led to a reduction of the stone's internal cohesion and to a loss of artistic, historical, material, and cultural value. Although the contribution of heritage to sustainable development has been absent from the mainstream about this subject, UNESCO has been recently highlighting its relevance across its various dimensions (social, environmental, and economic).

Conservation interventions, involving consolidation of stone, are often required due to their advanced state of degradation that threat the cultural value and significance of the built heritage.

Consolidation intends to restore the cohesion between superficial and in-depth particles of severely damaged stone to avoid irreparable loss of the stone substrate. Consolidation is thus frequently necessary to restore the cohesion and the unique solution to avoid the complete loss of stone elements, to guarantee their preservation and avoid the necessity of replacement of the existent stone objects by new ones.

Although the availability of commercial consolidants and their satisfactory results in some stones, such as alkoxy silanes in situations of granular disintegration in silicate stones, their performance in carbonate stones has not been equivalent, and often show a reduced efficacy or even potential to accelerate degradation phenomena. Their tendency to crack and the lack of chemical affinity with carbonate substrates are the most cited drawbacks and the reasons behind their poor performance. Thus, the conservation of carbonate stones has been an open challenge that claims research for designing novel and efficient strategies to guarantee the safeguarding of the heritage.

The aim of NanoCStoneH project was to develop a new generation of products for the consolidation of carbonate stones varieties present in built heritage, applying an integrated and ambitious approach combining nanotechnology, composite materials and

performance assessment. The integrative approach covering these fundamental aspects was innovative and ensured a better performance of the new products developed in comparison to those available on the market, which contributed for a more sustainable conservation of Heritage.

Ançã stone (porous limestone) and Trigaches marble (Figure 1) were the selected carbonate stones for assessing the performance of the new consolidants developed.

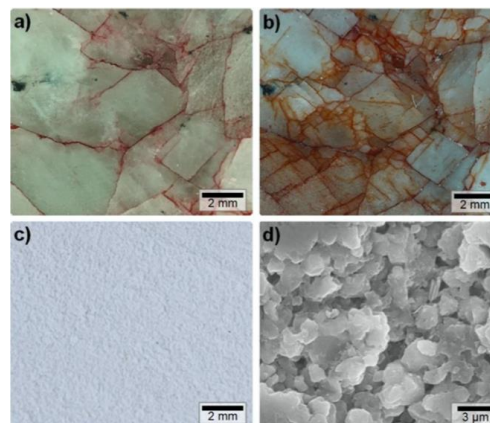


Figure 1. Trigaches marble impregnated with red dye before and after being artificially aged (a and b); Ançã stone (c and d)¹.

The design of the new nanohybrid consolidants (alkoxy silane-based formulations) was supported on an optimized methodology that was drawn and validated by the research team (Figure 2).

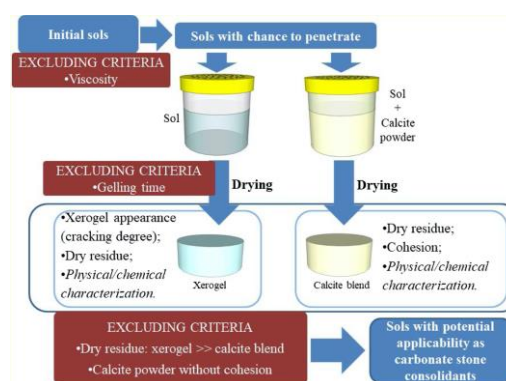


Figure 2. Second step of the methodology proposed to support the development of alkoxy silane-based consolidants for porous carbonate stones: from the initial sols to sols with potential applicability as carbonate stone consolidants².

¹ B. Sena da Fonseca, A.P. Ferreira Pinto, A. Rodrigues et al., Ability of novel consolidants to improve cohesion of carbonate stones: Dependence on pore-shape, aging conditions, and treatment procedures. Journal of Cultural Heritage 55 (2022) 95–106.

² B. Sena da Fonseca, A.P. Ferreira Pinto, S. Piçarra, M. F. Montemor, Alkoxy silane-based sols for consolidation of carbonate stones: Proposal of methodology to support the design and development of new consolidants, Journal of Cultural Heritage 43 (2020) 51–63.

Project Reference

PTDC/ECI-EGC/29006/2017

Leading Institution

IST-ID – Associação do Instituto Superior Técnico para a Investigação e Desenvolvimento (Portugal)

Partners

IST-ID: CQE – Center for Structural Chemistry (Portugal), IPS – Polytechnic Institute of Setúbal (Portugal)

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CERIS Research Team

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Funding

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Period

2018-2022

Total

229 249.50€

CERIS

156 724.50€

Project Website

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New consolidation products were developed with improved characteristics resorting to different catalysts and strategies, such as the use of organically modified alkoxysilanes, flexible hydrophilic polymer chains, hydrophilic silica nanoparticles and hydrophilic nano sized wires in tetraethoxysilane-based (TEOS-based) sols.

The project was carried out by a team of recognized researchers from varied scientific fields, such as Construction, Materials, Chemistry and Geology, with proven experience in the

built heritage conservation and in the development of pioneering products.

The research team and the facilities made available (CERIS, CQE, IPS) guarantee a cross fertilization interdisciplinary approach to develop and assess the performance of the new consolidation products, allowing to generate innovative knowledge and practices, far beyond the state of the art and the current practice of conservation with impact at a national and international level.