

## Development of new consolidation products for porous carbonate stones

### Summary

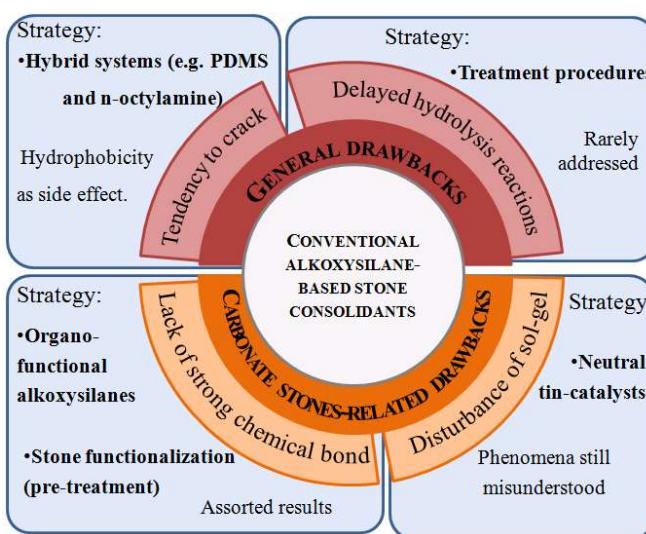
Products based on alkoxy silanes are the most well-known and used consolidants to treat stones from built heritage. However, their overall performance in porous carbonate stones is poor due to their lack of chemical affinity with carbonate minerals and due to the influence of the carbonate media in sol-gel reactions, while their tendency to crack and dependence on the atmospheric conditions are also factors constraining their behavior (see Figure). The major aim of this doctoral work is to develop new and alternative alkoxy silane-based products specifically dedicated to consolidate porous carbonate stones by addressing the above mentioned drawbacks. The strategy followed, relying on systems based on precursor, water and solvent, originated products with a reduced susceptibility to be influenced by the carbonate media and atmospheric conditions, while further modifications through the incorporation of polymeric chains and amino-functional alkoxy silanes resulted into products with different behaviors. Other strategies to tackle the lack of chemical affinity, based on the functionalization of the substrate, revealed little interest as pre-treatments, despite allowing to disclose further alternative single treatments.

The comparison between the overall performance of new products and some of the most well-known alkoxy silane-based consolidants available on the market exposed the interest of the developed alternative solutions.

Chemical development stages led to an in-depth study of the chemical interactions, which allowed to achieve a better comprehension on constraining phenomena and constitutes an important step forward, whereas the study on the use of artificial weathered stones to assess the efficacy of consolidants and other testing methods are also important contributions of this doctoral work. Additionally, a study methodology with exclusion criteria wherein the potential of applicability and chance to consolidate porous carbonate stones are assessed during the initial stages of development was established and is proposed in order to guide the chemical development-related decisions according to practical requirements of consolidation of porous carbonate stone.

### Keywords

Porous carbonate stones, consolidation, alkoxy silanes, development, performance.



Summary of drawbacks commonly appointed to conventional alkoxy silane-based stone consolidants and strategies followed for their overcome.



### PhD student

Bruno Monteiro Sena da Fonseca

### PhD program

Civil Engineering (IST, University of Lisbon)

### Supervisor

Maria de Fátima Montemor (CQE, IST, University of Lisbon)

### Co-supervisors

Ana Paula Santana (CERIS, IST, University of Lisbon) and Susana Gonçalves (CQE, IST, University of Lisbon)

### Period

2014-2018

### Funding

FCT scholarship (SFRH/BD/96226/2013)