Limiting salt crystallization damage in lime mortar by using crystallization modifiers

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Abstract

Salt crystallization is a recurrent cause of damage in porous building materials. Lime-based mortars, which were widely used in construction of ancient masonry, are especially prone to salt damage, due to their low mechanical strength. Existing solutions to tackle salt damage in mortars have been mainly focused on increasing the mechanical strength of the mortar by the replacement of lime with (Portland) cement, or on reducing the moisture transport capacity by the addition of silicone-based water repellent products. Both solutions often showed to have a limited resistance to salt decay and a low compatibility with historical buildings.

In the last years research has started to explore the possibility of influencing the crystallization mechanism by the use of crystallization modifiers. Modifiers are ions or molecules that prevent nucleation (inhibitors), promote nucleation of a certain crystal polymorph (promoters) and/or modify the habit of the crystals (habit modifiers). The modifiers can alter the level of supersaturation at the moment of crystallization, as well as the rate of crystallization, which may result in a lower crystallization pressure and/or enhanced drying and increased salt crystallization at the surface of the material. Consequently, they may reduce salt damage development.

In previous research, borax ($Na_2B_4O_7 \cdot 10H_2O$) has been identified as a potential modifier for sodium sulphate, being one of the most damaging salts [1]. Borax is expected to promote the crystallization of mirabilite, the

decahydrate polymorph of sodium sulfate, at a lower supersaturation level than without modifier. A reduced supersaturation level at the moment of crystallization leads to a lower crystallization pressure and consequently less damage. The effective concentration of borax in sodium sulfate solution has been defined to be in the range of 0.01 to 0.1 M [1]. The promotion of mirabilite instead of for example thenardite, the anhydrate polymorph, is possibly the result of the formation of a template layer of borax. The crystal lattice parameters of borax and mirabilite have a high similarity, resulting in epitaxial growth [2].

However, there are still many fundamental questions to be answered about the impact of such a modifier before the ideal outcome is achieved for our specific application in the area of cultural heritage.

In this poster we show some microscale experiments using direct imaging and optical microscopy [3] in order to study the dynamics of crystallization of sodium sulfate in the presence of borax. The nucleation and growth and the crystallization patterns of sodium sulfate are followed during droplet evaporation on a glass plate at controlled relative humidity and temperature for different concentrations of borax in the solution. Additionally the impact of the borax concentration on the surface tension and the wetting properties of sodium sulfate solution were measured using the drop weight technique and the KRUSS apparatus.

Future research will also include crystallization experiments in glass micro capillaries, in order to simulate crystallization in pores. The ultimate aim of this research is to develop a lime-based repair mortar, with built-in crystallization modifiers.

Keywords: crystallization modifiers, lime mortar

References

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