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Scientific Program

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Obtaining of self-cleaning repair air lime mortars with photocatalysts

M. Pérez-Nicolás¹, I. Navarro-Blasco¹, A. Duran¹, R. Sirera¹, J.M. Fernández¹, J.I. Alvarez¹

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The obtaining of self-cleaning mortars is very interesting to apply them in Built Heritage. Atmospheric pollutants, mainly carbonaceous particles and gases like NOx and SO2 can lead to severe aesthetic and functional damages in artworks. In the case of mortars and renders, the use of photocatalysts -usually based on TiO₂- can be worthy of consideration. Photocatalysts, after being activated by light, are able to oxidize pollutants avoiding their deposition onto building materials.

In this work, different air lime mortars modified upon the addition of TiO₂-based photocatalysts were obtained and studied. Photocatalysts can be incorporated in bulk or as an active coating onto hardened specimens. In both cases, the degree of the photocatalytic agent dispersion as well as its compatibility with dispersing agents was taken into account. The changes in fresh state properties were studied as well as the effect of the presence of the photocatalysts on the pore structure and mechanical resistance.

Finally, a detailed study of the self-cleaning efficiency of these materials was carried out by means of a NOx abatement test. Results showed that the presence of the photocatalysts had a positive impact on the preservation of the lime mortars characteristics.
Obtaining of self-cleaning repair air lime mortars with photocatalysts


Department of Chemistry, MIMED Research Group
UNIVERSITY OF NAVARRA

Santorini, 12 October 2016

Introduction

Atmospheric pollution and its impact onto Built Heritage

- NOx are thought among the toxic gases in polluted atmospheres responsible for ozone depletion and acid rain.
- In addition, the interaction of NOx could lead to damages onto building materials and the accumulation of the degradation products and dirt induces detrimental aesthetic consequences.
- Generally speaking, many different pollutants and particulate matter could give rise to dirt accumulation onto stones and mortars.

How can we face up to this atmospheric pollution?

Photochemical oxidation (PCO) has been used in the last years and has gained a great attention.

PCO involves the use of photocatalysts, semiconductor transition metal oxides.

Semiconductors have an electronic structure characterized by a filled valence band and an empty conduction band. When the energy provided by a photon (light source) matches or exceeds the band gap, one electron overcomes the energy barrier and is promoted from the valence band to the conduction band, leaving a hole (positive charged) in valence band.

In the presence of air and oxygen, compounds are adsorbed on the semiconductor surface and the next step is their photo-oxidation.

What are the most widely used photocatalysts?

- TiO2 is a stable, non-toxic and highly efficient photocatalyst under ultraviolet (UV) light. It is by far the most common photocatalytic agent.
- TiO2 has two crystal structures: rutile and anatase which band gaps are 3.02 and 3.23 eV respectively. PCO reactions are more effectively with anatase owing to: (i) its conduction band location, which is more favourable in order to conduct conjugate reactions; and (ii) to its stability in the formation of surface peroxide groups.
- Previous successful TiO2 addition in building materials as Portland Cement with effective results in terms of NOx abatement as well as of self-cleaning ability of their surfaces.

Conclusions

1) The tested photocatalysts were perfectly compatible with the air lime to be included as bulk addition in mortars, as proven by:
   - Mortars showed acceptable mechanical strengths and good durability in the face of freezing-thawing and sulfate attack cycles.
   - Porous structure underwent no dramatic changes.
   - There was not apparently modifications concerning colour or shine.

2) Lime mortars without additive exhibited a certain ability for NO abatement.
3) Under UV illumination, samples with bare TiO2 yielded the best NO abatements, reaching a 38% of NO removal. Doped TiO2 also yielded satisfactory NO removal rates.
4) Under visible radiation Fe/TiO2 exhibited the most efficient NO abatement in all proportions.
5) The application of coatings yielded excellent NOx removal rates.
6) Different systems were tested to avoid agglomeration of the photocatalyst nanoparticles. Isopropanol was proved to be a good dispersion medium. The use of dispersing agents (plasticizers), such as melamine sulfonate or Tween 80, increased the effectiveness of the coatings.

THANK YOU FOR YOUR ATTENTION