HMC 2016

4th Historic Mortars Conference

Scientific Program

10th -12th October 2016

Santorini, Greece

www.HMC2016.com

Laboratory of Building Materials
Dept of Civil Engineering
Aristotle University of Thessaloniki

Organizing Committee

Papayianni Ioanna Professor AUTH

Stefanidou Maria Associate Professor AUTH

Palyvou Clairy Emeritus Professor AUTH

Pachta Vasiliki Dr Architect, Conservator AUTH

Scientific Committee

Binda Luigia Politecnico di Milano, Italy

Biçer-Şimşir Beril The Getty Conservation Institute, USA

Bokan Bosiljkov Violeta University of Ljubljana, Slovenia

Groot Caspar Delft University of Technology, Netherlands

Hughes John University of the West of Scotland, Scotland

Jornet Alberto University of Applied Sciences and Arts of Switzerland, Switzerland

Lindqvist Jan Erik Cement & Concrete Research Institute, Sweden

Maurenbrecher Paul National Research Council of Canada, Canada

Middendorf Bernhard Technische Universität Dortmund, Germany

Papayianni Ioanna Aristotle University of Thessaloniki, Greece

Pachta Vasiliki Aristotle University of Thessaloniki, Greece

Piqué Francesca University of Applied Sciences and Arts of Switzerland, Switzerland

Stefanidou Maria Aristotle University of Thessaloniki, Greece

Tedeschi Christina Politecnico di Milano, Italy

Toniolo Lucia Politecnico di Milano, Italy

Toumbakari Eleni Hellenic Ministry of Culture, Greece

Valek Jan Academy of Sciences, Czech Republic

Van Hees Rob Delft University of Technology, TNO, Netherlands

Veiga Maria-Rosario National Laboratory for Civil Engineering, Portugal

Velosa Ana University of Aveiro, Portugal

10:00 - 10:15	**Holistic methodology for the mix design of hydraulic grouts in strengthening historic masonry structures**, Androniki Miltiadou-Fezans and Theodosios P. Tassios	**Application of acoustic microscopy technique for the evaluation of the renders applied to masonry**, Georgios Karagiannis, Maria Stefanidou, Georgios Apostolidis, Katia Matziaris
10:15 - 10:30	**Influence of resins on the properties of lime-pozzolan grouts for surface consolidation**, Vasiliki Pachta, Ioanna Papayianni	**Obtaining of self-cleaning repair air lime mortars with photocatalysts**, M. Pérez-Nicolás, I. Navarro-Blasco, A. Duran, R. Sirera, J.M. Fernández, J.I. Alvarez
10:30 - 11:00	Discussion	Discussion
11:00 - 11:30	**Coffee break**	
11:30-13:30	**Session XVI / Advances in repair materials and technologies concerning historic structures and archaeological sites** Hall A **Chair:** Maria Stefanidou, Inigo Navarro	**Session XVII/ Grouts for repair of historic masonry and architectural surfaces** Hall B **Chair:** Francesca Pique, Vasiliki Pachta
11:30 - 11:45	**Properties of lime-based pastes with nanosilica**, Cristiana Nunes, Zuzana Slížková, Maria Stefanidou	**Repeatability and reproducibility in measuring injection grouts properties: three grouts, two operators**, Chiara Pasian, Andreja Padovnik, Francesca Piqué, Albert Jornet
11:45 - 12:00	**Pozzolanic mortars with nano-TiO2 for restoration applications: physico-chemical and mechanical assessment,** K. Kapetanaki, C. Kapridaki, N. Maravelaki	**Rheology of natural hydraulic limes for masonry repair**, PFG Banfill, LEH Shimizu
12:00 - 12:15	**Optimization of hydraulic lime mortars with nano-SiO_2**, Loucas Kyriakou, Magdalini Theodoridou, Ioannis Ioannou	**Consolidation of lime renders. Study of some consolidation treatments applied in multilayer renders**, Rita Nogueira, Ana Paula Ferreira Pinto, Augusto Gomes

Obtaining of self-cleaning repair air lime mortars with photocatalysts

M. Pérez-Nicolás[1], I. Navarro-Blasco[1], A. Duran[1], R. Sirera[1], J.M. Fernández[1], J.I. Alvarez[1]

[1] MIMED Research Group, Department of Chemistry and Soil Science, School of Sciences, University of Navarra, Spain, jalvarez@unav.es, mimed@unav.es

The obtaining of self-cleaning mortars is very interesting to apply them in Built Heritage. Atmospheric pollutants, mainly carbonaceous particles and gases like NO_x and SO_2 can lead to severe aesthetic and functional damages in artworks. In the case of mortars and renders, the use of photocatalysts -usually based on TiO_2- 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 TiO_2-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 NO_x 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

M. Pérez-Nicolás, I. Navarro-Blasco, A. Duran, R. Sirera, J.M. Fernández, J.I. Alvarez

Department of Chemistry, MIMED Research Group

UNIVERSITY OF NAVARRA

Santorini, 12 October 2016

Introduction

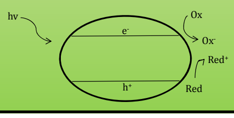
Atmospheric pollution and its impact onto Built Heritage

- NO_x are thought among the toxic gases in polluted atmospheres **responsible for ozone depletion and acid rain.**
- In addition, **the interaction of NO_x 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**.

Introduction

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 bad 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.



Introduction

What are the most widely used photocatalysts?

- **TiO_2 is a stable, non-toxic and highly efficient photocatalyst** under ultraviolet (UV) light. It is by far the most common photocatalytic agent.
- **TiO_2 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 TiO_2 addition in building materials as Portland Cement** with effective results in terms of NO_x abatement as well as of self-cleaning ability of their surfaces.

$$TiO_2 + h\nu \rightarrow e^- + h^+ \quad (1)$$
$$H_2O + h^+ \rightarrow H^+ + OH\bullet \quad (2)$$
$$O_2 + e^- \rightarrow O_2\bullet^- \quad (3)$$
$$NO + O_2\bullet^- \rightarrow NO_3^- \quad (4)$$
$$NO + OH\bullet \rightarrow HNO_2 \quad (5)$$
$$HNO_2 + OH\bullet \rightarrow NO_2 + H_2O \quad (6)$$
$$NO_2 + OH\bullet \rightarrow NO_3^- + H^+ \quad (7)$$

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 TiO_2 yielded the best NO abatements, reaching a 38% of NO removal. Doped TiO_2 also yielded satisfactory NO removal rates.
4) Under visible radiation Fe-TiO_2 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

ευχαριστίες