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DEVELOPMENT OF METAL-ALKOXIDES PRECURSORS FOR CONSERVATION NANOMATERIALS: THE EU PROJECT NANOMATCH

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Introduction

Deterioration of historic building materials has become more and more important since climate change has worsened the natural decay and the impact of atmospheric pollution. On the basis of these premises, the three-year European Collaborative Project NANOMATCH addresses this issue through the development of innovative consolidants specifically designed to meet the requirements of the historic building substrates, especially focusing on stone, wall paintings, wood and glass, and integrated in high performance products to renovate the market dedicated to the conservation of the built heritage.

Concept and objectives

Although knowledge on deterioration processes of building materials have been greatly improved, no really effective solutions to preserve and protect these materials have been found yet. Moreover, the performance of many products applied in conservation and restoration activities has recently been drastically reconsidered due to their physico-chemical ageing and consequent economic disadvantages because of the poor efficiency of the treatment [1].

As an alternative to organic conservation materials, NANOMATCH proposes the use of metal alkoxides as molecular precursors for the deposition of metal carbonate as consolidants for carbonate stone and wooden materials and metal oxide as a glass consolidant.

The expected features making them competitive compared to conventional conservation products are their (*i*) compatibility with the main materials used in built heritage like stone and wood -even painted- and glass, ensuring enhanced durability, re-treatability, sustainability

and efficiency, (*ii*) easy and safe handling during applications, (*iii*) adequate commercial prices.

Description of work

Alkaline earth and semimetal alkoxides are suitable molecular precursors of consolidants for stone, wood and glass because the corresponding solutions or nano-particulate inorganic sols, upon evaporation of the solvent based carrier, undergo hydrolysis and condensation or carbonation inside the porous structure of the substrate. This turns out in a nano-structured coating adherent to the substrate pore walls (stone, wood) or to internal cracks (glass).
Moreover, the resulting compounds, carbonates and/or oxides, have the property-by appropriate molecular tuning according to the substrate requirements- to be stable under major physical, chemical and microbial attacks, restoring integrity and mechanical properties of the original matrix.

Particularly calcium alkoxides, acting as precursors of corresponding carbonate [2], can be considered for stone strengthening as an indispensable and essential preliminary action for its conservation, as demonstrated within the bilateral Italian-French GALILEO Project [3]. The same material will be used for wood as these materials, besides strengthening effects, also ensure an alkaline supply to mitigate acidic deterioration processes of cellulose structures. Within the project activities it has also been demonstrated that magnesium alkoxides evolve to unstable carbonates that might be deleterious for stone conservation [4].
Regarding the innovative glass material, a molecularly dispersed aluminum alkoxide complex (A18), was developed within the EU-project CONSTGLASS. Its promising properties as glass-in-glass consolidant are due to its very low viscosity that allows its penetration in the smallest capillaries of corroded glass. After solvent evaporation, the micro porous residue consists of an aluminum oxide precursor, which subsequently hydrolyses very slowly leading to an oxide network chemically bonded to the silicate surfaces of the cracks [5].

To reach these objectives the research has been performed as here summarized:

- Different synthesis routes have been tested and more than 20 different alkoxides have been produced in order to identify the right products and the suitable methodology for its production at industrial scale,
- Application methodologies have been developed in laboratory in order to select a restricted number of alkoxides to be tested, their concentration and the most suitable solvents to be used,
- mechanical, microclimatic and physic-chemical tests, also after artificial weathering, are in progress in laboratory and in field to assess the durability, compatibility and effectiveness of newly synthesized materials.

The selected sites for the assessment of materials performance are the Monumental site of Santa Croce in Florence (Italy), the Cologne Cathedral in Germany, the Oviedo Cathedral (Spain) and Stavropoleos Monastery in Bucharest (Romania) (Figure 1). They are located in polluted and climatologically different areas so that the effects of the different environmental conditions can be evaluated.

Figure 1. Examples of field tests on wood and stone specimens running at Oviedo Cathedral and Stavropoleos Monastery (Bucharest) respectively.

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References

[1] M.J. Melo, S. Bracci, M. Camaiti, O. Chiantore, F. Piacenti, 1999. Polym. Degrad. Stab., 66, 23-30
[2] Ossola F., Tomasin P., De Zorzi C., El Habra N., Chiurato M., Favaro M., 2012., New J. Chem., 36, 2618–2624
[3] S. Duchêne, V. Detalle, M. Favaro, F. Ossola, P. Tomasin, C. De Zorzi, N. El Habra. Nanomaterials for consolidation of marble and wall paintings. In: Proc. 12th International Congress on the Deterioration and Conservation of Stone, Columbia University, New York 22-26 Oct 2012
[4] Favaro M., Chiurato M., Tomasin P., Ossola F., El Habra N., Svensson I., Beckers E., Forrat Pérez V., Romero Sánchez M., Bernardi A., 2013 Calcium and magnesium alkoxides for conservation treatment of stone and wood in built heritage, in: on-line Proc. Built Heritage 2013 Monitoring Conservation Management, 18-20 Nov 2013
[5] Brinkmann, U., et at. 2010. The CONSTGLASS Project: Screening of Conservation Campaigns and Material Development for the Sustainable Preservation of European Stained-Glass Windows. in "The Art of Collaboration Stained-Glass Conservation in the Twenty-first Century", Harvey Miller Publishers, London, 144-150