

Innovative materials for the conservation of stones in historical architecture: the experience of the NanoCathedral consortium

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The development of innovative nanomaterials for the conservation of natural stone in the context of historical architecture is a strategic task in Europe, considering the huge amount of buildings, churches and sites with centuries of outdoor exposition and the troublesome adverse environmental conditions of the polluted urban areas.

Despite the literature of the last decade and the knowledge about nanomaterials, the properties of the nanomaterials applied to natural stones are only partially explored and assessed. The NanoCathedral Project (EU Horizon 2020 - GA 646178) developed and tested, in the period 2015-18, new materials, technologies and procedures for the conservation of deteriorated stones in monumental buildings and cathedrals and high value contemporary architecture, with a particular emphasis on the preservation of the originality and specificity of the stone substrates.

For what concerns the conservation of deteriorated stones in polluted atmospheres the main challenges are:

1. Surface consolidation, to strengthen the crystalline matrix of natural stones by replacing lost original mineral bridges, and partially recovering lost mechanical properties);
2. Surface protection, to prevent the ingress of liquid water and pollutants and the formation of biofilms, without any change in aesthetical, optical and mineralogical/chemical properties of the substrate.

Nanostructured consolidant (nano-silica, nano-calcite, nano-hydroxyapatite) and protective (added nanoparticles TiO₂, Ag, ZnO) treatments, have been designed, set-up, and prepared by the SMEs with the collaboration of different researchers, and the specific properties and performances of the stone/nanomaterials systems have been carefully studied in laboratory and onsite conditions.

The innovative formulations have been applied on 6 different lithotypes (Ajarte fossil limestone, Balegem sandy limestone, Obernkirchen and Schlaitdorf sandstones, St. Margarethen calcareous arenite and Apuan marble), selected among the stones used in five medieval cathedrals (Vitoria-Gasteiz, Ghent, Cologne, Vienna and Pisa) and a contemporary theatre (Oslo Opera House), which are emblematic of different European geological and environmental areas.

An overview of the architecture of the Project, of the innovative materials and of the main achievement and results will be presented, with a more detailed focus on protective materials and the experimental approach that has been implemented in laboratory and in situ.