New nanomaterials for the conservation of historic limestone buildings

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Limestones are a type of stone that has been widely used as construction material since ancient times, and its preservation is imperative for the conservation of historical buildings. Preliminary studies on the causes of the decay in monuments of Seville (Spain) conclude that biodeterioration, together with other weathering elements, is major risk factor that leads to the deterioration of our Cultural Heritage constructions. In addition, the increase of other detrimental external factors, such as pollution, accelerates the stone degradation processes, what results in the need for frequent interventions for maintenance and restoration, especially using consolidants to recover stone cohesion and/or biocides to inhibit biofilm formation. Different treatments are currently employed for this purpose but, in many cases, these products have shown important disadvantages, i.e., shortlisting effect, possible incompatibility with the substrate stone or high toxicity to humans and the environment.

New treatments based on nanoparticles have been designed, synthesized and tested as consolidants or biocides for limestones. Regarding consolidant treatments, we have developed a new nanocomposite based on calcium hydroxide and zinc oxide nanoparticles with fluorescence properties that allow us to check the surface intervened and measure easily the penetration depth of the treatment under ultraviolet light. The comparison with other consolidants allows us to conclude that this new treatment has good results and is longer lasting than other established treatments.

In the case of biocide, we have designed and synthesized silver and silver/titanium dioxide nanoparticles, which have shown a high capability to inhibit algal biofilms. The use of correct concentration allowed us to avoid undesirable aesthetical changes while, in the case of white limestones, it is possible to use other nanoparticles with similar results, i.e., zinc oxide nanoparticles. In addition, new techniques, such as LIBS, have been applicated for measuring the penetration depth of metals nanoparticles inside substrate stone, or optical coherence tomography (OCT) for analyzing the thickness layer caused by consolidants or biofilms over the surface stone.