Silica nanocontainers antimicrobial coating for sustainable Built Heritage protection

Andrea Campostrini, Elena Ghedini, Michela Signoretto, and Federica Menegazzo

CATMAT Lab, Department of Molecular Sciences and Nanosystems, Ca' Foscari University of Venice and INSTM RUVe, Via Torino 155, 30170-Venice, Italy

E-mail: andrea.campostrini@unive.it

Although the conservation of materials of cultural interest is becoming a more and more sensitive topic for the scientific community, it is still strongly connected to traditions and the empiric knowledge of small handicraft companies. These procedures are usually hight effective, but, especially when dealing with biological degradation phenomena, they are often not updated to the latter scientific innovations and hence do not always consider the impact of their use on the environment. Evidently antifungal and antimicrobial products are genuinely poisonous for natural organisms, nevertheless, as Paracelsus, pioneer of Renaissance medicine, wrote: "Everything is poisonous: nothing exists non-poisonous. Only the dose ensures that the poison has no effect". Hence, our attention must be driven to the concentration and disposal (i.e. washing-off) of these restoration products.

Most antimicrobial cleaning products need a washing-off procedure after their application, but while when dealing with small objects the washing water collection is quite an easy procedure, when it is a facade or monument which needs to be cleaned, most of the time the water is just left flowing into the ground. Another main issue, concerning the environmental impact of the restoration procedures, is the need to reapply the antimicrobic product quite often to maintain the surface free of dangerous microorganisms, hence having an economical and product higher dispense [1].

In this work, some porous silica-based materials (i.e. SBA-15 and MCM-41) were investigated as nanocontainers to hold and gradually release the two commercial biocide products Benzalkonium Chloride and Biotin T – a mixture of n-octyl-octhilinone and quaternary ammonium salts. The nanocontainers were embedded in a matrix made of TEOS and siloxanes (e.g. PDMS) to homogeneously suspend the particles, also modulating the coating's hydrophobic properties. In fact, with the proposed system it would be possible to avoid the previously mentioned problem of collecting washing waters since the coating does not need to be rinsed; moreover, the need to often reapply the antimicrobic product no longer subsists, thanks to the use of the controlled release system, which have a longer effect over time. To better hold the antimicrobic compound in the silica-based materials, and hence control the release concentration, the silica nanocontainers were grafted with sulfonic groups via a post-grafting method in a NaCl water solution [2]. The materials were characterized by XRD, FT-IR, TPO, and TEM analyses and then the release was measured by UV spectroscopy analyses.

Concluding, in this work, it was possible to develop a sustainable antimicrobial coating, based on silica nanocontainers with controlled release features, able to maximize the antimicrobial performances and in general the protective action.

[1] E. Franzoni et al. "Applicability of life cycle assessment methodology to conservation works in historical building: The case of cleaning." *Energy and Buildings* 214 (2020): 109844.
[2] C. Pizzolitto et al. "Effect of grafting solvent in the optimisation of Sba-15 acidity for levulinIc acid production." *Catalysis Today* 345 (2020): 183-189.

This work is funded by the European Union – NextGenerationEu, by the PON R&I 2014-2020/ IV.5 – GREEN action, and the Unione Stuccatori Veneziani – Uni.S.Ve. s.r.l. company