Ecofriendly Antimicrobial Agents and Biocleaning Treatment for the Conservation-Restoration of Cultural Heritage

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Biodeterioration is one of the main causes of the material degradation of cultural heritage. Natural biocides could represent a valid and safer alternative to conventional ones. In particular, essential oils (EOs) from plants, rich in antimicrobial components, and naturally occurring phenols are environmentally friendly and can be considered a green alternative to control biodeterioration. Formulation of EOs and natural phenols can be an effective strategy to overcome some issues (as color, high volatility, insolubility in water and degradability) for use in cultural heritage remediation.

The object of the first part of the work concerns the first example of the application of ecofriendly polymeric nanocapsules (NCs), based on biodegradable and biocompatible polymer, loaded with *Origanum vulgare* (Or) or *Thymus capitatus* (Th) essential oils, to protect marble stones from bacterial colonization [1]. Antibacterial activity of these potential natural biocides against two bacterial strains, *Escherichia coli* (Gram negative) and *Kocuria rhizophila* (Gram positive), were performed on 18th century marble sample from an altar in restoration at the San Francesco Borgia church in Catania (Italy). The EO-NCs were able to inhibit the bacterial grow on the stone pretreated with bacterial inoculum. The obtained results evidenced the potential of these nanoencapsulated natural biocides in the treatment of biodeteriorated cultural heritage. Naturally occurring phenols can be considered a green alternative to control biodeterioration of cultural heritage affected by bacteria. Hydroxylated biphenyls are widely present in nature and represent an important source of bioactive compounds [2]. We tested naturally occurring phenols, their C2 dimers and the corresponding β CD inclusion complexes prepared by straightforward methods. β-cyclodextrins are sustainable matrix material able to include phenols in its structure and to activate a controlled release of the guest to maximize the efficacy of the biocide. According to that, we tested the efficacy of the selected phenols and their β-CD complexes against *K. rhizophila* and *E coli.*

Finally, the use of extremophile bacteria (ICB strain library) to remove nitrate salt efflorescence from the surfaces of stone materials (biocleaning) was studied for the first time, in collaboration with Drs. Abbate and D'Orazio of IPCB (Pozzuoli), by using *Halomonas campaniensis*, a haloalkaliphilic nitrate-reducing bacterium. Nitrate cleanings by the extremophilic microorganism tested can be considered environmentally friendly and therefore advantageous also in comparison with physic-chemical methods, that generally require the use of solvents, excessive removal of the original material, etc. In particular, water-based methods to remove nitrate can damage the stone because nitrate can be transferred in the deep by water. Moreover, the use of extremophilic microorganisms can conversely ensures the safety of interventions in the absence of risk, because they need growth conditions to proliferate that do not correspond to those of most living beings. After treatment, no *H. campaniensis* viable cells are able to survive, hence, no negative effects due to metabolism of viable cells potentially remained on the treated items are to be expected, indicating that *H. campaniensis* is comparatively safer for bio-treatment of cultural heritage.

Keywords: Ecofriendly antimicrobial agents; extremophiles bacteria; biocleaning

References:

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