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ACTIVE CONSERVATION OF CERAMIC BUILDING MATERIALS: REMOVAL OF LICHENS ON ROOF TILES BY LASER AND BIOCIDES TREATMENTS

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Very recently, in monumental cities, certain conservational practices tend to use ancient/traditional roof tiles in the restoration of Heritage buildings. Numerous studies have been undertaken to remove lichens on stones. However, little has been done to date to study lichens removal from ceramic materials, despite the fact that they are commonly colonized by different lichen communities. The main goal of this contribution is making a diagnosis of alterations that lichens may cause in ceramic materials, as well as to determine the possibilities of removal by treatments based on laser irradiation and use of biocides.

Different calcareous (CaO> 5 wt.%) and non-calcareous (CaO< 5 wt.%) roof tiles with biological colonization (mainly lichens) coming from Segovia and Guadalajara provinces in the center of Spain, were considered for the assessment of laser-biocide combination effects during cleaning tests. Three species were identified: *Pyrenodesmia teicholyta*, *Calogaya decipiens*, and *Verrucaria nigrescens*, which grow in a different way regarding the distinct composition of the ceramic substrate. The tiles chemical composition and mineralogy were characterized using X-ray fluorescence (XRF), X-ray diffraction (XRD) and optical polarized petrographic microscopy respectively. Laser irradiation was carried out by applying sequences of ns laser pulses of two wavelengths (1064 and 266 nm). After laser treatment a biocide from Thor Especialidades SA was applied. The treatment consisted of ACTICIDE CL1, Advansil PMR and ACTICIDE CF. To assess the effect of the laser irradiation, and the combination with the use of biocides, several techniques were applied, including stereomicroscopy to describe morphological changes, fluorescence microscopy to observe the viability of the algae, scanning electron microscopy (SEM) at low vacuum to analyze the effects on the surface of lichens, SEM-BSE images to study the effects of treatments inside the thalli, transmission electron microscopy (TEM) to observe cytological induced alterations, and FT-Raman spectroscopy to detect possible structural and chemical changes. In the case of *V. nigrescens* the dual laser irradiation removes many areolae, while in the cases of *P. teicholyta* and *C. decipiens*, only some areas of the thalli were detached. In this case, the cortex of the thallus was partially removed, thereby exposing the photobiont. TEM observations shown some holes produced by laser irradiation in different layers of the thalli, whereas fluorescence microscopy revealed distinct decreasing vitality of alga cells within the lichen thallus treated with biocide. FT-Raman spectra corroborated the partial removal of lichens and showed the presence of calcium oxalate produced by the reaction of lichens oxalic acid with the calcium present in the tiles. The resulting data and conclusions of this study could be extrapolated to other ceramic materials such as bricks and wall or floor tiles.

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