science and technology. Contributions include short communications, technical notes, description of activities in specialised centres, announcements of jobs and conferences, forthcoming publication of conference proceedings, special issues, dissertations, etc., as a way to share news and information. The newsletter will be published on January and July and is open to anyone who has an interest in cultural heritage. It will last as far as we receive inputs and contributions for the subscribers.

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**LICHEN DETERIORATION OF CONSOLIDANTS USED IN THE CONSERVATION OF STONE MONUMENTS**

X. Ariño and C. Saiz-Jimenez

*Instituto de Recursos Naturales y Agrobiología, CSIC, Sevilla, Spain*

Lichens are widespread in Baelo Claudia, a Roman city founded in the second century B.C., and near present-day Tarifa, Cádiz, Southern Spain (Ariño et al., 1995; Ariño and Saiz-Jimenez, 1996). Baelo Claudia is representative of a small industrial city with an economy that was based on fishing, especially tuna from the Straits of Gibraltar, and its trade made it one of the wealthiest cities in the Mediterranean.

The Roman city was discovered in the second decade of the XXth century. The forum and the temples of the city, after excavation in 1971, appeared relatively well preserved. The climate of the area is dry but mild, with relatively heavy rainfall in winter, although in summer there are long periods of aridity.

Since exhumation there has been a gradual deterioration of the stuccoed walls and column capitals. More than twenty years ago, some stuccoed capitals showing heavy decaying processes were consolidated with a resin to preserve the altered surface. Polymer analysis showed that the resin used was a polyester resin, prepared from polyfunctional aromatic acids and fatty acids, as denoted the recovery of different esters of benzene(poly)carboxylic acids and C16 fatty acids. Although there is some data on the susceptibility to biodeterioration of resins (Salvadori and Nugari, 1988; Koestler and Santoro, 1988; Koestler et al., 1988) this phenomenon was never reported for lichens.

During a visit to Baelo Claudia to study the deterioration processes of stuccoed walls and pavements, a considerable lichen colonization of several consolidated stuccoed capitals was observed (Figure 1a). Five species of lichens were identified growing on the consolidated stuccos: *Caloplaca lactea* (Massal.) Zahlbr., *Caloplaca citrina* (Hoffm.) Th. Fr., *Sarcogyne regularis* Körber, *Verrucaria muralis* Ach. and *Lecania turicensis* (Hepp) Müll. Arg. (Figure 1b-f). All species were growing beneath the resin layer and, in addition, *C. citrina* was growing on the outer surface of the deteriorated resin. These species are very common on the sandstone of this archaeological area (Ariño et al., 1995) and frequently occur on stone monuments and man-made substrata (Deruelle et al., 1979; Nimis et al., 1987; 1992).

For SEM study, samples were fixed with glutaraldehyde (2 %), dried at room temperature and gold coated. To obtain cross sections some samples were submerged in liquid nitrogen and fractured with forceps.

Cross section through the resin-lichen-mortar shows that the lichens are placed between these two materials (Figure 2a,b), forming a dense network of hyphae and algae, with fruiting bodies emerging through the resin layer (Figure 1b). The hyphae network invaded the resin revealing damages due to extensive perforation, pits having a diameter of 2-4 µm (Figure 2c). Observations with fluorescence microscope showed undamaged chlorophyll proving that the photobiont cells were alive. The lichens were active rather than being preserved.
specimens of lichens that were coated by the resin as demonstrated the extensive holes caused in the resin.

Figure 1. a) Stuccoed capital consolidated with resin. b) Apothecia of Sarcogyne regularis Körber emerging from the resin. Scale = 500 μm c) Resin deterioration produced by Verrucaria muralis Ach. growth. Scale = 100 μm d) Detail of the interface resin-V. muralis. Scale = 50 μm e) Emerging fruiting body of V. muralis. Dissolution of the resin apparently accompanied by mechanical action due to pressure from the fruiting body, shown by the fracture line (arrows). Scale = 100 μm f) Development of a fruiting body of S. regularis in a resin pit. Scale = 200 μm

No report book or data could be obtained for the restoration works accomplished years ago and to whether the stuccoed capitals were cleaned before resin treatment. However, the evidence of living lichens causing resin destruction and survival beneath a layer of resin points to the development of a cryptoendolithic strategy, as only the soredia, apothecia and perithecia were in contact with the exterior. It could be speculated that lichen penetration occurs through the fissures and cracks of the resin layer, invading the interface resin-mortar which could be considered as a protective niche for lichen growth by retaining humidity in a extremely windy and, to some extent, xeric environment, and permitting sufficient light to pass through it. It was observed that lichen structures emerge by exerting pressure on the resin until it is ruptured (Figure 1e). Together with this mechanical action, a chemical effect is clear, as the margins of the resin around the reproductive structures were rounded and showed signs of apparent chemical dissolution (Figures 1c, 1d and 1f). Also the holes produced in the resins (Figure 2c) add further evidence for a chemical effect. In samples of the resin layer without lichen colonization, these types of deterioration were not observed. The fact that deterioration of the resin layer took place only in these definite areas suggests that living lichens cause resin destruction. Survival of lichens beneath a layer of this polymeric resin is clearly supported by Figures 1 and 2 and confirms the high colonization capacity of many lichens for different materials.

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References
NEW OPTICAL SENSORS FOR MONITORING ACID ENVIRONMENTS IN PREVENTIVE CONSERVATION

M. García-Heras\textsuperscript{1}, N. Carmona\textsuperscript{2}, C. Gil\textsuperscript{3} and M.A. Villegas\textsuperscript{1}

\textsuperscript{1}CENIM, CSIC. Madrid, Spain
\textsuperscript{2}Fraunhofer-Institut für Silicatforschung, ISC. Wertheim, Germany
\textsuperscript{3}Centro Nacional del Vidrio. La Granja (Segovia), Spain

Introduction

Environmental acidity causes deterioration (Leissner, 1996) in inorganic materials (metals, alloys, ceramics, glasses, enamels, etc.); as well as in organic materials (paper, tissue, leather, wood, bones, etc.). The measurement and control of environmental acidity is not always a simple task. Preventive evaluation of environmental pH should involve a brief, reversible, reliable and reproducible procedure. Our objective was to design, produce and evaluate a family of pH sensors with optical response based on thin glassy films. Such sensors will be sensitive to acid chemical species present in the air, especially in polluted environments.

Design and preparation

Thin films prepared by the sol-gel method (Mackenzie and Bercher, 2000) are suitable for the encapsulation of organic dyes (OD), capable of changing their optical absorption (colour) when acidity varies (Shahriari and Ding, 1994). These ODs can be used as environmental pH indicators when encapsulated into a partially densified glassy coating (Villegas et al., 2002). The experimental procedure for obtaining the coatings was as follows: a silica based sol (colloidal suspension) is firstly prepared, starting from a silicon alkoxide that undergoes hydrolysis and slow polycondensation. When hydrolysis is achieved the sol is doped with the OD, in such a way that OD molecules are entrapped in the inner surface of the silica network during further polycondensation and partial densification of the glass-like network. Thin coatings were applied upon common glass slides by dipping the slides in the doped sol, and then withdrawing them at a constant rate (5 to 30 cm min\textsuperscript{-1}). The coatings thickness varied between 150 and 500 nm. Once obtained, the coatings were submitted to a soft thermal treatment (60°C for 3 days), in order to polymerise the silica network and densify the system formed by the coating and the glass substrate. After that, the coatings were thin, transparent, coloured films capable of behaving like acidity sensors under wet gaseous conditions, i.e. they are sensitive to acid/basic chemical species combined with the atmospheric water (even below 40% relative humidity). This method for sensor production is versatile enough to allow the use of ODs of very different sensitivities in a given zone of the pH range. Hence, the possibilities for obtaining sensitive materials applicable in preventive conservation strategies are, in fact, promising.

Figure 1. Absorption spectra of a sensor at acid and basic pH