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Deleterious effect plastic-based biocides on back-ventilated granite facades

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A B S T R A C T

In Galicia (northwest Spain), the mild humid climate causes the walls of many buildings to be permanently damp, which leads to the appearance of phototrophic colonization ("greening") on the walls. Prolonged, deeply penetrating damp can be halted by the application of plastic-based products. Ventilated facades are separated from the structural wall, which enables the protective products to be applied to the back of the facade. This is an important advantage since it allows the use of coloured paints, which would be unacceptable for use on the exterior face of a building, and other plastic-based compounds that are degraded by solar radiation. The main aim of this laboratory-based study was to evaluate the usefulness of several plastic-based products (*viz.* white plastic paint, Sikaflex®, Tegosivin®, and Tegovakon®) for inhibiting biological colonization on the exterior faces of buildings when applied to the back of the stone cladding. The results of the study demonstrated an unexpected effect: the application of plastic-based products to the back of specimens simulating ventilated granite facades does not inhibit biological colonization, but increases the tertiary bioreceptivity of granitic rocks.

1. Introduction

Cleaning is an important aspect of the maintenance and rehabilitation of stone buildings and structures. Colonizing microorganisms contribute substantially to the fouling of buildings, which causes aesthetic as well as physical and chemical damage to the building materials (Seaward, 1979; Grant, 1982). In Galicia (NW Spain), the climate is oceanic, and the atmospheric humidity is high because of the high rainfall and the mild temperatures that occur throughout the year. This leads to many building surfaces being permanently damp, which favours biological colonization, the development of biofilms and thus the formation of greenish patches, in a phenomenon commonly referred to as "greening" (Fig. 1). Previous studies (Gaylarde et al., 2004; Barberousse et al., 2006a,b) have shown that green microalgae and cyanobacteria are the main constituents of "greening" on building facades. The growth and development of these microorganisms, and the subsequent recruitment of other microorganisms, cause aesthetic damage to buildings and favour deterioration of the underlying material (Ortega-Calvo et al., 1991; Tiano, 1993; Saiz-Jimenez, 1994; Tomaselli et al., 2000; Crispim et al., 2003; Sterflinger, 2010).

In order to arrest the impact of green biofilms, water availability, which is the main environmental factor that limits growth of microorganisms (Bellinzoni et al., 2003), and the bioreceptivity of the material, *i.e.*, its aptitude to be colonized by living organisms (Guillite, 1995), must be decreased. Different chemical products that act as water repellents and decrease the bioreceptivity of building facades are widely available nowadays. However, these products require preliminary testing in the laboratory with isolated strains of microorganisms, to determine their compatibility and effectiveness on the materials in question (e.g., Krumbein, 1993; Young et al., 1995; Urzì and De Leo, 2007; De Muynck et al., 2009; Fonseca et al., 2010). This information is essential for researching new methods capable of preventing the process of biodeterioration in buildings. The use of some commercially available plastic-based products in outdoor environments is increasingly discouraged because of the potential ecotoxicity of such products and the fact that they do not promote long term protection, mainly because they are washed off the surfaces of buildings by rain and therefore need to be repeatedly applied (Russell and Chopra, 1996; Fonseca et al., 2010). However, the

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Fig. 1. The Hejduk Towers in the *Cidade da Cultura de Galicia* (Santiago de Compostela, Northern Spain) constructed with a ventilated facade and showing extensive phototrophic colonization ("greening"). The towers were built between September 2002 and February 2003. The granite used for the ventilated facades is Azul Extremadura with a sawn finish.

modern building system known as ventilated facade allows the products to be applied to the back of the exterior wall, as stones slabs are attached to the exterior face of the structural wall, creating an air cavity between the structural wall and the stone cladding (Fig. 2). This is an important advantage since it enables the application of plastic-based products that otherwise could not be applied to the exterior face of buildings, e.g., coloured paints and products that are degraded by solar radiation.

The main aim of this laboratory-based study was to evaluate several plastic-based products (white plastic paint, Sikaflex®, Tegosivin® and Tegovakon®) as potential inhibitors of biological colonization on the exterior faces of buildings. The products were applied to the back of stone specimens simulating ventilated granite facades, to reproduce the phenomenon of natural biological soiling. The effects on the tertiary bioreceptivity of the samples were also studied.

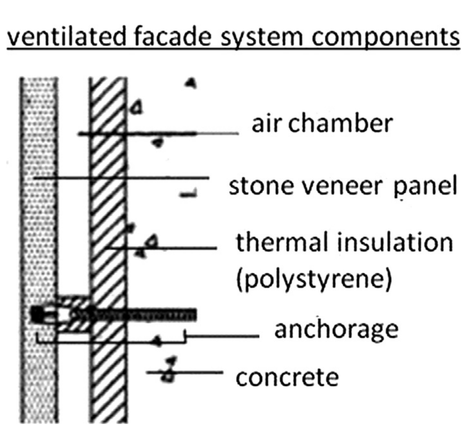

Fig. 2. Components of the rain screen of the ventilated facade system.

2. Materials and methods

2.1. Experimental setup, inoculum preparation and inoculation of test specimens

A laboratory experiment was designed and conducted to evaluate the effectiveness of four plastic-based products: white plastic paint, Sikaflex®, Tegosivin®, and Tegovakon®, as inhibitors of biological colonization on the exterior faces of buildings. This involved inoculating a mixed culture of algae and cyanobacteria on one side of *Silvestre Moreno* granite samples (dimensions $5 \times 5 \times 1$ cm), the opposite side of which had previously been treated with the plastic-based product.

In order to obtain mixed cultures, samples of microbial communities from green biofilms were collected from the vertical outer walls, built with *S. Moreno* granite, from a building located in A Coruña (NW Spain). Biofilm biomass was scraped from the wall with the aid of sterilised instruments, placed in sterile tubes and transferred in the laboratory to Erlenmeyer flasks containing 200 ml BG-11$_0$ liquid culture medium (Rippka et al., 1979) and to Erlenmeyer flasks containing 200 ml Bold's Basal Medium (Bischoff and Bold, 1963); the flasks were then incubated at 26 °C under 12h/12h light/dark cycles for 90 days. After that period, the cultures were mixed together for 30 days.

S. Moreno granite samples were inoculated with 3 ml of the mixed culture (1.7 μg chlorophyll-a ml^{-1}) and maintained for 45 days in stationary conditions in a climatic chamber at 26 °C, 75% humidity and 12 h light/12 h dark to promote growth of the organisms.

2.2. Assessment of biological growth

Biological colonization of the inoculated side of the samples was monitored periodically (0, 15, 30, and 45 days) by measuring the