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POSTER ABSTRACT

The use of cyclododecane as a separating layer during the moulding of porous stones

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The physicochemical properties of outdoor moveable artworks are modified by degradative environmental agents and biodeterioration. In many cases, the most effective action or intervention is to replace an artwork with a copy, moving the original into a museum or another more protected place. In general, this process entails moulding of the original (Maish and Risser 2002) and its reproduction using restoration mortars (Mas i Barberà *et al.* 2013).

This study evaluates the possibility of using cyclododecane (CDD) as a temporary barrier film during the moulding of extremely porous stone sculptures and ornaments (Hangleiter *et al.* 1995; Hangleiter 1999; Rowe and Rozeik 2008; Riggiardi 2010). For this, samples of a travertine (calcium carbonate rock) called Tosca Rocafort were prepared (Figure 1). These travertines, exceptionally porous with numerous cavities, can be percolated in an irreversible way by moulding materials during the process of making a copy. By using a CDD barrier layer, the pores are sealed without losing the texture of stone substrate, and at the same time the silicone moulding material is prevented from penetrating the porous stone. To solve the problem of an affinity between the CDD and the silicone (both of which are non polar materials), several polar substances (4% agar-agar in water and pure latex) were applied as an intermediate insulation layer (Figure 2).

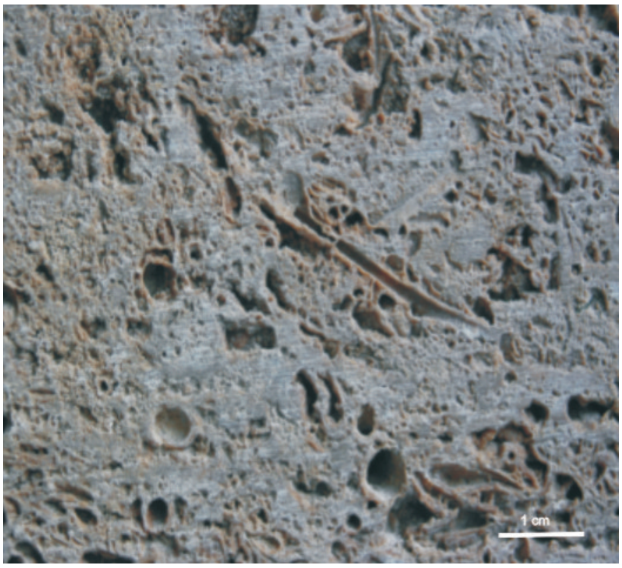

Figure 1 Tosca Rocafort is a travertinic limestone with a macroporous structure, extracted from the quarries of Rocafort (Valencia, Spain). Photo: X. Mas-Barberà.

For this study, samples of Tosca Rocafort stone were cut (dimensions 16 × 4 × 4 cm). Likewise, different CDD solutions in white spirit were prepared. Greater concentrations of CDD have a higher viscosity, so areas with large pores were sealed with 90% CDD solution, while lower viscosity solutions were used to increase penetration in areas with medium pore size (70% solution) and fine pore size (50% solution). All layers of the moulding system, both polar and non polar, were applied by brush, creating a uniform film. The stone samples coated with CDD were tested by irradiation with ultraviolet light in order to detect possible CDD residues. The isolation layers were also subjected to photoageing (1000 hours of exposure), which showed that latex left no residue, but agar-agar left residues on the surface of the stone. The results were obtained through spectrophotometry, optical microscopy and Fourier-transform infrared spectroscopy (FTIR). At the same time, the resulting CDD films were characterised using cryogenic scanning electron microscopy (cryo-SEM).

This proposed method, based on a system of layers with different polarities, allowed us to isolate and protect the porous stone from the silicone elastomer, which is the cause of irreversible stains on stone substrates during mould-making. As an

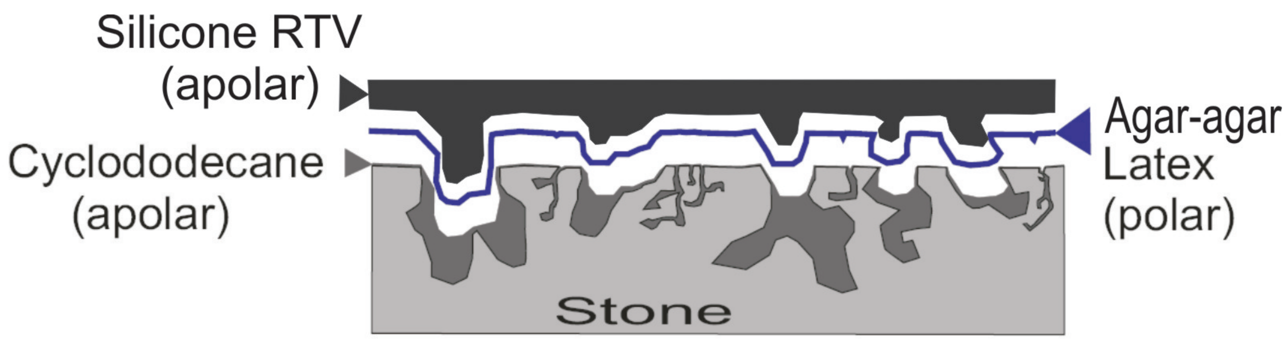

Figure 2 Diagram of the polar–non polar bi-layer system applied to the porous stone. Image: X. Mas-Barberà.

isolation layer, agar-agar proved unsatisfactory as it formed heterogeneous layers with low physical resistance, resulting in residues of moulding materials on the stone suface. In contrast, latex created homogenous layers while transmitting all details of the surface of the original work – and without leaving residues. The presented multi-layer system for moulding of porous materials has a number of advantages that make it appropriate for conservation and restoration work: good film-forming properties, very low toxicity, and ready reversibility (due to the ability of CDD to sublimate (Figure 3)). The CDD film remains in place for long enough to allow the silicone moulding material to become vulcanised. However, it is easily removed through sublimation, which means that no intervention (possibly damaging to the surface of the stone) is necessary to remove the barrier layer. We conclude that CDD is a suitable temporary barrier material on porous stones, creating a homogeneous, impervious and inert film.

Figure 3 Photomicrographs (×8 magnification) of the macroporous surface of the Tosca Rocafort stone with the non polar CDD layer: a–c) during application of CDD; and d) during sublimation. The CDD creates a homogeneous layer that impedes contact between the moulding substances and the stone. After the sublimation of the CDD, the stone remains unaffected. Photo: X. Mas-Barberà.

Biographies

Xavier Mas-Barberà has a PhD in Conservation and Restoration of Cultural Heritage (Universitat Politécnica de Valéncia-UPV, Valencia, Spain, 2006). He is a professor of Sculpture and Ornaments Conservation and Restoration at the Faculty of Fine Arts, UPV. He has a particular interest in the study of alterations and interventions to stone materials, which he pursues at the Institute for Cultural Heritage Conservation, UPV. Since 2007, he has been responsible for the stone materials section, with a focus on the development of new materials and methods (cleaning, desalination, consolidation, moulding, copying and protection processes) for the treatment of sculptures and ornaments carved in stone.

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Stephan Kröner has a PhD in Geology (Johannes Gutenberg University Mainz, 2005). He completed his undergraduate degree at the Karlsruhe Institute of Technology (Germany) in 1998 and moved to the University of Lausanne (Switzerland), where he obtained his degree in Geology (2000). During his diploma and doctorate, he specialised in the field of structural geology, geochronology and isotope geology in order to understand mountain-building processes in the Alps and the Damara Orogen (Namibia). In 2007, he moved to the Institute for Cultural Heritage Conservation (IRP) at the Universitat Politécnica de Valéncia-UPV, where he was responsible for the characterisation of inorganic materials (stones, ceramics, pigments, mortars, etc.). Since 2014, he has collaborated as external staff with the IRP-UPV. Currently, he works at the CPI2020 Foundation (UPV) as a proposal writer for the European Horizon 2020 funding programme.

Javier Orozco-Messana has lectured on materials science, ceramics and several scientific topics at the Universidad Politécnica de Valéncia-UPV since 1986. He has also lectured at Florida State University. He was Research and Development Manager in several private companies (AIMME, Lladro, Autocares Luz) between 1990 to 2004. He has been responsible for more than 5 research projects at European, national and regional level. For 6 years he was secretary at the Valencian Association for Industrial Engineers and apart from his academic responsibilities he is currently Director for International Affairs at UPV, where he is responsible for the coordination of several Erasmus Mundus Consortia.

J.V. Grafiá-Sales has a PhD in Conservation and Restoration of Cultural Heritage (Universitat Politécnica de Valéncia-UPV, Valencia, Spain, 2004). He is a professor of Sculpture and Ornaments Conservation and Restoration at the Faculty of Fine Arts (UPV).

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