

## The removal of intractable materials with an Erbium:YAG laser at 2.94 $\mu\text{m}$ from ancient tempera painting on panel

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The deterioration of a 15th century Spanish panel painting by Lluís Borrassa (1365-1425) *Christ before Pilate* was scientifically studied for the first time to devise a method to remove intractable restoration materials from the painting surface.

In a previous restoration, performed in the first half of the 20th century, a pigmented varnish of a dark amber colour was applied on the surface in order to conceal damages to the colours and give uniform tone to the paint losses. Therefore, the painting was in need of cleaning because the dark old varnish obscured the design and colours of the picture. In particular the blue of the Christ figure robes, which appeared black, and required extreme attention to the compromised state of conservation of the pictorial layer composed of lapis lazuli and the delicate binding material.

The overall result of these treatments was that an intractable layer of material was left behind which needed to be carefully removed with a method not affecting the original painting layers, especially the under bound lapis lazuli of the blue robe in Christ's figure.

To understand and to solve such problems, it was fundamental to identify the materials, which have been used by the artist and which were applied by restorers. Moreover, in order to understand the oxidation pattern undergone by the materials themselves extensive identification analysis of the organic and inorganic materials, both original to the painting and those applied in previous restorations, were carried out.

A multi-analytical approach based on VIS-Ultra Violet images, Gas Chromatography-Mass Spectrography (GC-MS), also coupled with a pyrolyzer (PY/GC-MS), Fourier transform-infrared spectroscopy (FTIR) and Scanning Electron Microscopy (SEM-EDX) techniques have been employed, and herein presented. The results showed, among others, the presence of materials such as proteinaceous compounds and polysaccharides. These compounds are ideal products that can be removed by laser ablation at 2.94  $\mu\text{m}$ , and explain the inability to remove the dark incrustation with traditional methods, without damaging the original surfaces.

The acquired new knowledge guided the conservators to choose and test some cleaning methods and finally adopt the appropriate Er:YAG laser cleaning method.