Advanced methods for the analysis of Roman wall paintings. Elemental and molecular detection by means of synchrotron FT-IR and SEM micro-imaging spectroscopy

Lucilla Pronti[1*], Martina Romani[1], Giacomo Viviani[1], Chiaramaria Stani[2], Patrizia Gioia[3] and Mariangela Cestelli Guidi[1].

[1] INFN-Laboratori Nazionali di Frascati, via Enrico Fermi 40, 00044 Frascati (Rome), Italy;
[2] Beamline SISSI, Elettra, via Padriciano 99, 34012 Basovizza, Trieste, Italy;
[3] Sovrintendenza Capitolina ai Beni Culturali, Piazza Lovatelli 35, 00186, Rome, Italy

* Correspondence: lucilla.pronti@lnf.infn.it ID: 0000-0003-4384-1814

Abstract:

The reconstruction of Roman decorative apparatus from delocalized fragments is an arduous challenge for the archaeologists. An archaeometric approach may integrate the archaeological analyses, based on the stylistic observations, improving the ability to merge adjacent fragments, especially in absence of distinctive ornamental elements. In this work the capacity of Reflection FT-IR spectroscopy combined to chemometric tools to identify groups of fragments that have similar chemical composition of the pictorial layers is tested. Synchrotron radiation-based Fourier Transform infrared (SR-FTIR) microspectroscopy coupled with Scanning Electron Microscopy (SEM) and Energy Dispersive X-ray micro-analysis (EDX) performed on cross section were used to enhance the performance of conventional FT-IR technique and to localize micrometric-size compounds. The chemometric approach proposed in this work turns out to be a powerful way to discriminate pictorial layers with similar chemical composition, by the identification of different compounds. The use of SR-source has permitted to improve the lateral resolution and to discriminate neighboring micro-compounds, such as quartz and cuprorivaite in Egyptian blue pigments.

Keywords: FT-IR, *SR-FTIR, Roman wall paintings, pigments, reflection FTIR, SEM-EDS*

1. Introduction

Among the Cultural Heritage materials, Roman wall paintings represent an interesting matter to investigate (Gil-Torrano et al. 2019; Linn et al. 2019; Mateos et al. 2018; Moretto et al. 2011; Salvadori et al. 2019).

Although the style of Roman paintings are well recognizable and identifiable by specific decorative elements, the use of pigment mixtures, pictorial stratifications or unusual compounds is not always fully understood and it may be distinctive of certain ornamental motifs or contain important information about local productions and trade routes (Aliatis et al., 2010; Mazzocchin et al 2006, 2007; Villar et al. 2005).

An accurate study of Roman wall paintings becomes necessary especially when these are found as incoherent fragments that must be relocated in their original location or in exhibition spaces. In these cases, if we assume that adjacent fragments present the same chemical composition of the pictorial layers, archaeometric investigations could become an useful tool for the analysis of those fragments that do not preserve any distinctive decorative marker enabling the scientific reconstruction of the decorative apparatus.

For this purpose, an extensive analyses of the chemical composition of the pictorial layers can be focused not only to the identification of the main compounds (minerals or organic matter) which determine the color of the pictorial layers but also to the accessory items that are responsible of a variety of shades or certain aesthetic effects (Sbroscia et al., 2019).

Among the analytical methods applied in the analysis of wall paintings, Fourier Transform Infrared (FT-IR) spectroscopy was largely used for the characterization of pigments, especially in Attenuated Total Reflection (ATR) mode (Fermo et al. 2013; La Russa et al. 2009; Marey 2014). This acquisition mode, although permits a clear identification of the IR active molecules, cannot be applied in-situ and imposes a gentle pressure on the sample surface, leading to possible damages of the samples and/or of the ATR crystal, especially in the case of mural surfaces.

In recent years, Specular Reflection mode analysis has been widely used for the investigation of the chemical composition of cultural heritage due to the improvement of portable devices for *in situ* analysis (López-Ramírez et al. 2015; Rampazzi et al. 2017; Rosi et al. 2009).