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TR-FTIR techniques to support the conservation of metal surfaces: application to Renaissance gilded artefacts

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Non-invasive Fourier transform infrared spectroscopy (FTIR) methodologies in the field of conservation science have been of great interest in recent years, particularly those based on total reflectance (TR), both *in situ* TR-FTIR and TR-FTIR microscopy. Portable instruments offer the advantage of in-situ investigation, but there are some limitations due to both the probe head size and the investigated area width. Indeed, the probe diameter is about 5 mm with no possibility of assessing restricted areas of interest on the object. However, a FTIR microscope allows working on very small areas (down to a few hundreds of μm^2) of the surface of art objects or parts of them, if they are small enough to be placed on the microscope stage. Both methodologies are particularly suitable to investigate thin films on metal surfaces where the reflection-absorption phenomenon of the radiation may take place: the IR beam passes through a thin layer of the sample (coating or patina of corrosion products) and is reflected from the non-absorbing metal substrate. The method is essentially a double-pass transmission experiment, and the collected spectra resemble those obtained in transmission.

This paper presents case studies where the presence of a gold layer (amalgam or foil gilding) over bronze, silver or iron enabled the application of the non-destructive methods described above. The studies include a gilt element taken from a silver reliquary of the 15th century and a gilt iron panel of the 16th century, that were placed on the FTIR microscope stage; and Donatello's bronze sculpture of San Ludovico and bronze Pulpito della Passione, both investigated *in situ* with the portable instrument. The FTIR analysis on the artefacts shown in this work were carried out as part of conservation processes, which included cleaning and application of protective coatings.

The information resulting from the analysis proved to be very useful to underpin the restorers' work. The alteration products coming from the metal under the gold layer and/or the remains of coatings laid in the past were identified and, in some cases, their distribution on the surface was mapped. That helped to make an informed choice of the best conservation process to adopt. Based on the compounds detected, some cleaning methods were selected and applied on test areas. The different conservation procedures were evaluated by monitoring their effectiveness with TR-FTIR measurements.