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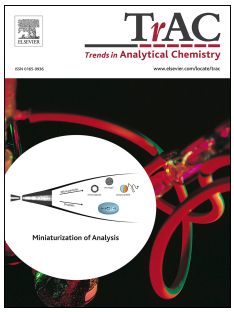

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New perspectives in the non-invasive, in situ identification of painting materials: the advanced MWIR hyperspectral imaging

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ABSTRACT: In the last few decades the development of advanced method for the non destructive, in situ analysis results in mapping and imaging analytical technique. Herein, the high potentiality of the advanced mid-wave infrared (MWIR) hyperspectral imaging (2700-5500nm) prototype are described to map organic and inorganic painting materials.The novel system and the experimental procedure, developed for mock-up paintings, were successfully applied to study of two 15th century easel paintings by Iacopo Vincioli and Niccolò Di Liberatore called Alunno.

Diagnostic techniques play a key role in the cultural heritage field, allowing specialists to investigate the constituent materials of artworks. The respect of an object's integrity and the necessity to obtain a spatial distribution of the materials, have led, in recent years, a great scientific interest towards developing new technologies for imaging and mapping methods. The potentialities of reflectance hyperspectral imaging in the visible (Vis, 400-700 nm) and in the near-infrared (NIR, 750-2500nm) spectral ranges for the investigation of works of art have been widely demonstrated [1,2,3,4,5]. However it is well known that this spectral region, where only overtone and combination bands of the functional group are present, lacks the specificity of the mid-infrared spectral data [6,7]. Despite mid-infrared spectroscopy in reflection mode having been routinely applied for the characterization of inorganic and organic painting materials [8, 9, 10] there are many doubts about the capabilities of a hyperspectral imager in the mid-IR spectral range in terms of both instrumental set-up and light level required (unsuitable for many artworks).

Rosi et al recently presented a LWIR hyperspectral imaging system, developed for the detection of gaseous compound, over a very restricted region (826-1300 cm^{-1}) specific for only limited number of materials [11].

The promising results achieved by means of a Mid-IR (3-5μm) reflectography on mural paintings [12] were encouraging.

For the first time we report the promising results obtained by a innovative mid-IR (2.7-5.5 μm) reflectance hyperspectral-imaging prototype system developed ~~hanks~~ thanks to the fruitful collaboration of Laboratorio di Diagnostica, Specim Spectral Imaging ltd. and LOT-Quantum Design s.r.l., to improve the spectral performances for the non-invasive in situ characterization of painting materials. A transportable 2D-scanner has been designed for acquiring data on a 160X160 cm^2 painting area, with a spatial sampling of 600 μm.

Two illumination sources, consisting in two tungsten bars located each in a quarter cylindrical mirror to concentrate radiation on a line, are mounted parallel to the painting surface with emission at 45° respect to the spectral camera MWIR focal axis to guarantee a uniform illumination. The optimized illumination system and a camera working distance of 50 cm allow to acquire with a frame rate of 150 Hz and an integration time of 3ms, of 90 mm/s. Such a fast scan (approximately 10s), along with an automatic sliding safety shutter placed in front of the illumination sources, allow to work in complete safety. The data hypercube is corrected, calibrated and elaborated by EVINCE software. Principal component analysis (PCA) is applied to spectral data and the first PC's are used for clustering and modeling of variables. Afterwards a Partial Least Square Discriminant Analysis (PLS-DA) model for predicting classes is performed.

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