Development of macro X-ray fluorescence (MA-XRF) and macro Photo-Luminescence (MA-PL) coupling

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The growing interest in scanning macro X-ray fluorescence (MA-XRF) stems from its ability to reflect pigment distribution within large areas on artworks by means of their elemental signature. MA-XRF appears thus highly complementary to other imaging techniques, such as X-ray radiography and UV/Vis/IR imaging. On the other hand, the photoluminescence (PL) response of heritage materials, in particular of pigments and binders, are actively investigated using laser sources as it is can be linked to the nature, synthesis, post-synthesis treatments and degradation of these materials [1]. The present development aims at extending the MA-XRF approach combined to the PL analysis. The scanner prototype allows the simultaneous scanning macro photo-luminescence (MA-PL) and MA-XRF of large areas of artefacts.

The MA-XRF system of the C2RMF is based on a collimated X-ray generator producing a sub-millimetre beam and Fast SDD detector. The instrument head is scanned in front of artworks using motorized translations and can cover a max area of 600 x 500 mm² with a resolution of 0.5 mm in 16h [2].

The MA-PL system is integrated in the MA-XRF scanner head. It can accommodate two excitation sources whose emission are conveyed to the sample through a 400-µm Ø UV-resistant fibers and Y adapter, a high energy pass filter and a collimator eventually producing a 500-µm illumination spot coinciding with the XRF analysis point. The PL emission is collected using a 1-mm Ø fiber connected to a CCD spectrometer (Ocean Optics QE65000, 200-1000 nm). The head is kept in focus using a telemetric pointer controlling translation along Z. The system was first applied to the investigation of the UV-PL response of areas painted using lead white pigment. In this case, the illuminating sources are two UV LEDs emitting at 250 and 365 nm which correspond to the excitation bands of interest [1] (Ocean Optics LLS250 and LLS365). The LED sources are gated in sequence during the dwell time. The system can be adapted to other excitation sources. For example, a UV LED can be replaced with a white source to collect reflectance map to compensate the PL emission maps from the intrinsic reflectance response of the artefact. An updated version of the open source MA-XRF program [2] simultaneously controls the head movements, records the PL and XRF spectra and stores MA-XRF and MA-PL maps in EDF format for processing using PyMCA program.

The first coupled MA-XRF and MA-PL maps obtained on an 18th c. historical painting will be presented and discussed.

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[2] E. Ravaud, L. Pichon, E. Laval, V. Gonzalez, M. Eveno, T. Calligaro, Appl. Phys.A 122, 2016, 17