Ultra-modern synchrotron-based microscopes for the study of ancient materials: a review of applications to Roman/Italian artefacts and/or by Italian researchers

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Cultural heritage has represented an important research activity at the European Synchrotron Radiation Facility (ESRF) for more than 15 years. At ID21, the spectro-microscopy beamline, this field represents about one third of the scientific activities (while main other fields are environmental science, life science and medicine). The ID21 X-ray and infrared microscopes have been regularly used to study various ancient and artistic materials, such as fragments from paintings, glasses, ceramics, wood, papyrus, photographs... [1] \( \mu \)XRF, \( \mu \)XRD, \( \mu \)XANES and \( \mu \)FTIR can be combined to obtain elemental maps, phase maps, speciation maps and molecular maps. These complementary pieces of information can be used to reveal manufacturing processes or to understand degradation phenomena. For what concerns Italian artefacts, the ID21 instruments have been used to study cinnabar degradation in Pompeian paintings [2], to reveal ink composition in papyrus from Herculaneum [3-4], to assess the origin of the colors and opacity in glasses [5-6], but also to study more modern materials such as 50’s plastic design objects [7]. Besides, some Italian user groups are also very active in analyzing major masterpieces abroad. As an example, the SMAArt Centre and Department of Chemistry, in Perugia, is expert in the development and application of portable instruments for the \textit{in-situ} study of artworks, and travel all over Europe to perform non-invasive analyses of artworks. But to go in more details into material composition and degradation, they may combine portable instruments with synchrotron-based micro-analyses performed on micro-fragments. They notably develop a strong research project about pigment degradation in 19\textsuperscript{th} C. paintings by van Gogh or Munch as well [8]. Some of these examples will be presented.

The ESRF is currently benefiting from a major upgrade, with the coming implementation of an “extremely brilliant source” (EBS). This upgrade will significantly increase the brilliance and coherence of the X-ray beam. In this context, the ID21 instruments are being deeply refurbished. The modification of X-ray optics is on-going with the objectives to extend the energy range (to \( \sim 2-11\text{keV} \)) and to obtain a smaller (\( \sim 100\text{nm} \)) and more stable beam. The X-ray microscopes will be completely re-designed to make their use more efficient and reduce set-up time. Software developments are also planned to improve data acquisition, data processing, data analysis and data archiving. Plans and schedule will be presented.

Figure 1. Some examples of artistic materials studied at ID21, by Italian users (eg van Gogh sunflowers [8]) or on Italian artefacts (plastic design objects [7], ink in Herculaneum papyrus [1, 3, 4], Pompein mural painting [2] and Roman mosaic tesserae from Aquilea [5]).


