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Degradation studies of cultural heritage materials using µ-XANES and µ-XRD

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The mission of cultural heritage institutions is to preserve and protect artifacts from the distant or more recent past for the enjoyment and education of current and future generations. In order to fulfill this mission in a professional manner, detailed knowledge on alteration phenomena of various kinds that gradually and unobtrusively are taking place at or below the surface of these objects is required. In order to be able to investigate the nature of these chemical transformations, that sometimes lead to the formation of microscopically thin alteration layers, the use of state-of-the-art microanalytical methods is required. Next to being able to provide information on the composition of various materials at or just below the surface, these methods also must be able to deliver highly specific information on the nature of the chemical compounds that are locally encountered. In this respect, our recent experience shows that the use of a combination of synchrotron X-ray based spectroscopic and imaging methods such as X-ray fluorescence analysis, X-ray absorption spectroscopy and X-ray diffraction can reveal significantly new information of certain alteration processes that have remained enigmatic for a long time. Concrete examples to be discussed is the darkening of originally yellow lead chromate paint layers, as encountered in paintings of V. Van Gogh [1,2] and the blackening of red cinnabar-based paint layers in works of Rubens [3]. In both cases, one or more microscopically thin alteration layers were encountered that are responsible for the colour and that contain resp. the metals Cr and Hg in other chemical environments that what they were originally.

[1] L. Monico, G. Van der Snickt, K. Janssens, W. De Nolf, C. Miliani, J. Verbeeck, H. Tian, H. Tan, J. Dik, M. Radepont, M. Cotte *Analytical Chemistry* **2011,** *83*, 1214-1224. [2] L. Monico, G. Van der Snickt, K. Janssens, W. De Nolf, C. Miliani, J. Dik, M. Radepont, E. Hendriks, M. Geldof, M. Cotte *Analytical Chemistry* **2011,** *83*, 1224-1231. [3] M. Radepont, W. de Nolf, K. Janssens, G. Van der Snickt, Y. Coquinot, L. Klaassen, M. Cotte *Journal of Analytical Atomic Spectrometry*, **2011**, DOI: 10.1039/c0ja00260g.

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X-ray computed tomography: a powerful diagnostic technique for art and cultural heritage

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Born in the early Seventies for medical applications, X-ray Computed Tomography is currently playing an increasingly important role in the field of Cultural Heritage diagnostics. In fact it represents a powerful non-destructive investigation technique, capable of displaying in a three-dimensional way the volume and the internal structure of the investigated objects, also thanks to modern 3D rendering techniques. This kind of information is very important for determining adequate conservation and restoration procedures [1] [2].

The first attempts in adopting this technique for Cultural Heritage analysis have been done by means of medical CT scanners, usually with courtesy and permission of an hospital. However, medical scanners are optimized for the human body (composed mainly by water) and cannot be successfully used on dissimilar objects like those of interest in the Cultural Heritage field. Moreover, it is difficult to move valuable works of art outside the museum in which they are located.

The great variety of size, shape and composition that is typical of archaeological findings and art objects requires the development of tomographic systems specifically designed for Cultural Heritage analysis and movable on-site, if necessary. In order to fulfill this request, our research group has set-up several CT systems, that make us able to perform high resolution micro-tomography of small objects (voxel size of few microns) as well as CT of large objects (up to 2 m of size). In fact, in order to perform good non-destructive evaluations, the most suitable CT system (source, moving equipment, detector and elaboration software) must be carefully chosen to avoid obtaining meaningless results. For small objects (i.e. fossil teeth and ancient jewels) radiation sources having a very small focal spot size and high spatial resolution detectors are required. For big or thick objects it is necessary to use highly penetrating radiation sources, very efficient detection systems and advanced mathematical methods for the reconstruction of the 3D images. Commonly X-ray tubes up to 450 kV are used, but a certain interest in high energy CT (more than 1 MV) is now growing up.

In order to highlight the versatility and the potential of Computed Tomography as a tool of knowledge in the field of Art and Cultural Heritage, we will present the results of several diagnostic investigations carried out by our research group, in collaboration with major restoration and conservation centers, both in Italy and abroad. Among the case studies that will be treated, it is worth mentioning the "Goldfinch Madonna" by Raffaello (CT carried out at "Opificio delle Pietre Dure" in Florence), two Japanese wooden statues of the XIII and the XVII century (CT performed at the Conservation and Restoration Center "La Venaria Reale" in Turin) and a Roman bronze Eros statue dating to the 1st century A.D. (CT scanning carried out at the Getty Conservation Institute, Los Angeles CA, USA).

[1] F. Casali, *X-ray and Neutron Digital Radiography and Computed Tomography for Cultural Heritage*, in: Physical Techniques in the Study of Art, Archaeology and Cultural Heritage, ed. by D. Bradley and D. Creagh, Elsevier, **2006**, *41*-123. [2] M.P. Morigi, F. Casali, M. Bettuzzi, R. Brancaccio, V. D'Errico, *Applied Physics A: Materials Science & Processing* **2010**, *100*, 653–661.

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Investigations of ancient Egyptian faience using XAS and PD

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Egyptian faience was produced over a period of approximately 5000 years, with the first examples dating to *ca*. 4000 BC. Faience is a glazed, quartz-based material that was commonly used to make objects such as beads, pendants, rings, tiles, bowls, jars, gaming pieces and specialist funerary equipment (e.g., [1, 2]). The most common colors are light and dark blue, probably developed to imitate valuable stones, such as turquoise and lapis lazuli, but other colors also occur, albeit less frequently. Faience is relatively common on archaeological sites

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