Combined use of Optical Coherence Tomography and macroXRF imaging for non-invasive evaluation of past alterations in 17th c. Dutch painting

Magdalena Iwanicka¹, Łukasz Ćwikliński², Piotr Targowski²

¹ Institute for the Study, Restoration and Conservation of Cultural Heritage, Nicolaus Copernicus University, ul. Gagarina 7, 87-100 Toruń, Poland, magiwani@gmail.com
² Institute of Physics, ul. Grudziądzka 5, 87-100 Toruń, Poland

Keywords: non-invasive imaging; optical coherence tomography; OCT; X-Ray Fluorescence Spectroscopy; macro-XRF; painting; overpaint; scanning

A 17th c. Dutch still life painting, signed J. Walscapele (Fig. 1) has been a subject of non-invasive examination as it brings specific conservation problems. The painting bears signs of many renovation/restoration treatments. Although some late retouchings along right edge of the painting are visible as dark areas, quenching UV fluorescence (Fig. 1 b), it was suspected that the yellowed and deteriorated varnish of strong UV-induced fluorescence obscures more of the possible past alterations and destruction phenomena linked to a rather brutal past lining treatment. The aim of the examination of the painting was to define and resolve non-invasively some of the conservation issues linked to past alterations.

Optical Coherence Tomography (OCT)¹,²,³ is an interferometric non-invasive technique of depth-resolved imaging within media scattering and/or absorbing near-infrared light moderately. Its ability of scanning centimetre-wide areas in order to obtain information about sequence, continuity and thickness of the subsurface layers makes it especially suitable for examination of easel paintings as well as other objects of art.⁴,⁵ Herein, a high resolution (2 μm axial, 12 μm lateral) spectral domain OCT instrument utilising near infrared (770–970 nm) radiation of 0.8 mW power beam at the object was employed. The still life was examined in 17 spots by means of OCT. OCT cross-sections (tomograms) are presented in a false colours. Warm colors correspond to high scatter/reflection of the probing light, whereas cold colours mark areas with low scatter. Transparent media (e.g. clear varnishes, glass or air above the surface of the examined object) or areas located beyond the range of penetration are shown dark.

Since OCT examination yields local structural information, we combined it with macro-X-ray fluorescence (macro-XRF; MA-XRF) method of elemental mapping, enabling extended surface scans (up to 70 cm x 55 cm) during a single examination, with lateral resolution up to 50 μm. For this study the M6 JetStream scanning system from Bruker Nano GmbH was used.⁶ It comprises a X-ray lamp working at 50 kV/600 μA conditions with Rh anode and a polycapillary optics. An open-air system permits imaging elements of atomic numbers not lower than 16 (S).

Macro-XRF scanning revealed that, apart from the pigments typical for the 17th c. (such as calcium based ground, lead white, vermillion, copper based green, ochres and umbers) vast areas of the painting are executed with zinc white and chromium green (pigments not used earlier than 19th c.). Especially the information that zinc white is present in almost all highlights needed further refinement. Naturally, if it had been part of the primary layers, this would overthrow the authenticity of the painting.
Fig. 1. *Sill life with a crab*, oil on canvas by Jacob van Walscapele, a: visible light; b: UV-induced fluorescence

In the figure (Fig. 2) a cross-sectional OCT view through the fragment of the painting is correlated with a macro-XRF images of lead and zinc distribution. Owing to the OCT tomograms it was possible to precisely locate the zinc-containing layer within the painting’s structure as ‘embedded’ between the layers of varnish, and, therefore, secondary (Fig. 2 d).

Fig. 2. *Sill life with a crab*, a: map of distribution of Pb-Lβ with MA-XRF; b: map of Zn-Kα distribution; c: photograph of the place of the OCT examination (yellow square), location of the OCT tomogram marked with white line; d: the OCT cross-sectional view (tomogram)
One microsample was collected for reference from the perimeter of a paint-loss near the lower edge of the painting. The observation of the cross-section in visible light and under ultraviolet illumination (Fig. 3) confirmed that the secondary paint layer is located between the varnishes.

Fig. 3. Sill life with a crab, cross-section of a sample collected from the area of a green tablecloth near the lower edge of the painting; a: visible light; b: UV-induced fluorescence. Magnification 100x. Description of layers: 1. ground layer, 2. underpaint, 3. blue paint layer, 4. primary varnish, 5. superficial dirt, 6. green paint layer (secondary); 7. two (?) varnish layers

The same structure of layers was found in all the examined areas, apart from the signature (Fig. 4), which is executed in umber (Mn and Fe were identified through MA-XRF scanning – Fig. 4 c,e) directly on the paint layer. There is no overpainting ‘embedded’ in the varnishes. This implies that the signature was not tampered with during the renovation and overpainting with zinc and chromium pigments.

Fig. 4. Sill life with a crab, region of the signature. a: map of Pb distribution with macro-XRF; b: map of Zn distribution; c: map of Fe distribution; d: map of Ca distribution; e: map of Mn distribution; f: visible light; g: microscopic photograph of the area scanned with OCT (yellow square), location of the OCT tomogram marked with white line; h: the OCT cross-sectional view (tomogram)
In conclusion, macro-XRF image of zinc distribution revealed the information that almost all areas of highlights are now executed in zinc white (the pigment not used earlier than 19th c.). Synergistic use of OCT enabled to precisely locate the zinc-containing layer within the whole painting’s structure, thus aiding in resolving both the amount and time of renovations of the painting.

References:


[2] Complete list of papers on application of OCT to examination of artwork may be found at http://www.oct4art.eu: Optical coherence tomography for examination of works of art, (accessed 20/10/2015).


Acknowledgements:

Financial support from the European Commission via IPERION CH: Integrated Platform for the European Research Infrastructure ON Cultural heritage - European Union Community's H2020 - Integrating Activities Research and Innovation Action (Grant Agreement 654028) is gratefully acknowledged. This research has been partially conducted with use of the research infrastructure of Interdisciplinary Centre for Modern Technology of N. Copernicus University in Toruń, Poland, financed by Regional Operational Programme for Kujawsko-Pomorskie Voivodeship (Project No.: RPKP.05.04.00-04-001/10).