

On site analysis of paintings by using portable instruments

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Analysis of a painting is important to understand the techniques of drawing and for the conservation of the art. Since a painting is composed of pigments with multilayer structure and pigments are a complex mixture of organic and inorganic chemicals, precious identification of pigments requires multi analytical techniques. Moreover, for study of precious art work, we have to bring analytical instruments to the artwork and non-contact analysis is required. Therefore, we have developed p-XRD, p-XRF, and p-UV-VIS-fluorescence spectrometer suitable for analysis of paintings. We also adopt commercially available micro-Raman spectrometer, portable IR spectrometer, and portable digital microscope.

We have been developing p-XRF [1] and p-XRD [2] since 2001 jointly with two X-ray manufacturers: i.e., OURSTEX Co. Ltd. and TechnoX Co. Ltd., respectively. Recently, we have also developed portable UV-VIS-fluorescence spectrometer jointly with Tokyo Instruments Co. Ltd. Our p-XRF developed is equipped with SDD with MOXTEK AP3.3 polymer window and vacuum sample chamber, which is suitable for analysis of light elements such as Na and Mg with monochromatic/white Pd X-ray sources. A new portable X-ray powder diffractometer suitable for on site analyses of paintings has been developed (see figure). Our p-XRD is composed of a theta-theta goniometer (4.5kg), a measurement-controller unit, and a lap-top computer. Our p-XRD adopted SDD as a detector and Cu X-ray tube (MAGPRO® 60 kV, 12W) which enables us to obtain good XRF spectrum as well as a good diffraction pattern with low background. Especially high voltage X-ray tube produces white X-rays with enough flux at high energy region suitable for XRF analysis of heavy elements from the same sample point of 2mm region. Our portable UV-VIS-fluorescence spectrometer is composed of UV-VIS source: DH-2000-BAL Deuterium, Halogen Light Source (Ocean Optics) ; LED(375,520,632nm) and Super Range Concave Grating Spectrometer (Stellar Net Inc.). The instruments were tested at real fields such as archaeological sites for analysis. Then, the results were reflected on the improvements of the instruments to achieve enough sensitivity, accuracy, and durability.

These instruments were brought to an archeological excavation site in Valley of the Kings, Luxor, Egypt to analyze wall paintings in New Kingdom. We have identified Egyptian blue, Egyptian green, huntite, orpiment and etc. We investigated the production technique of the Korin's "Red and White Plum Blossoms" screen produced in 18th century in Japan, a National Treasure. p-XRF, p-XRD, and micro-Raman were used to reveal the materials of various motifs. They included cinnabar, malachite and calcite. p-XRD analysis revealed the presence of metallic silver foil under the central river flow. It is found that black flow was produced with sulfurization of Ag to form acanthite Ag₂S. This discovery has revealed that the painting changed its appearance after 300 years. These instruments were also brought to Rijksmuseum in Amsterdam and we studied paintings by Vermeer, Rembrandt and etc. The most unusual discovery is the identification of Egyptian blue in a 16th century painting by the fluorescence spectrum and p-XRD analysis.

[1]I. Nakai and Y. Shindo, (2013)Modern Methods for Analysing Archaeological and Historical Glass, Ed. by K. Janssens, John Wiley & Sons, Ltd. 445-457

[2]I. NAKAI and Y. ABE,(2012) Applied Physics A,106,2,279-293



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