

Portable XRD/XRF for Cultural Heritage using Deep Cooled CCD Camera

Everyone loves to dream that they may unearth a masterpiece in their attic, a forgotten Rembrandt or a lost Picasso. When one does turn up it is often very difficult to determine if it is real or a fake. Art is a multi-billion-dollar business these days, insurance companies need to ensure that the artifacts they are providing cover for are genuine. It is also essential to understand the materials and techniques used by artists, to develop strategies for conservation and restoration.

There are lots of scientific techniques for establishing the authenticity of art. One area that is growing is the use of X-Ray Fluorescence (XRF) and X-Ray Diffraction (XRD), the analysis of a small region of an object to measure mineralogy and chemistry.

XRD is a 100+ year old technique used to study the structure of crystalline matter. It is routinely used to analyze geological samples, man-made materials, or pharmaceutical drugs. XRD was also deployed by NASA on Mars in the Curiosity rover to analyze Martian soils and rocks. XRF is a well-established method of quantitative element analysis that is based on the ionization of the atoms of the material being irradiated by an energetic beam of primary X-rays.

In the field of cultural heritage, XRD and XRF are very useful techniques but they usually require collecting a small sample from the object, which is destructive, or taking the object to a laboratory or a synchrotron facility, which is expensive, time consuming and not practical. A US based company, eXaminart LLC has developed a portable XRD/XRF system that enables art historians and conservation scientists to apply both XRD and XRF techniques in-situ.

Their Duetto 2 instrument couples a miniature X-ray source and a Raptor CCD camera to record the X-ray diffraction and fluorescence signatures of a small area of the surface of an object, enabling the identification of the materials, such as pigments in paintings.



Figure 1: The Duetto 2 system with a Raptor CCD camera

Using a method initially developed for the NASA Mars XRD/XRF instrument, both XRD and XRF data are extracted from a series of CCD exposures. During an analysis the CCD X-ray detector is read at intervals of a few seconds. Raw CCD data are processed in real time and XRD/XRF plots are visualized on the computer.

XRF data, obtained from the exact same spot of the object as XRD, are very informative and practical in helping with the phase identification of complex samples, or confirming the nature of the phases found independently by XRD.

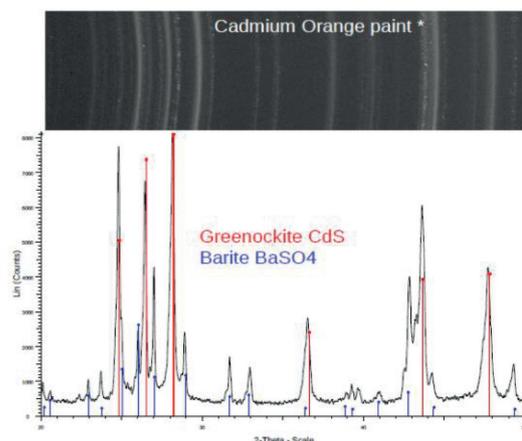


Figure 2a: 2D XRD pattern and diffractogram with phase identification revealing the presence of barite in the paint.

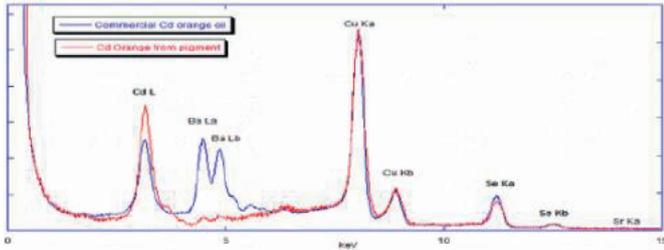


Fig 2b - XRF spectra of cadmium orange paint (blue) compared to pure cadmium orange pigment (red). The Ba signature in the XRF confirms the interpretation of barite in the XRD pattern.

The Duetto 2 system features:

- A miniature rugged body, making it the smallest XRD in the world
- Raptor Toucan deep-cooled CCD X-ray camera
- A miniature X-ray tube (Co or Cu)
- A micro-focused laser beam and embedded camera for precise positioning
- A very low power (40W) allowing use of lithium batteries for day-long operation
- Software / database library.

The system helps scientists to better understand the materials and techniques used by artists, to develop strategies for conservation and restoration, and to provide evidence for dating / authenticity purposes.

Images and data courtesy of eXaminart LLC, USA

<https://examinart.com/>

Raptor has worked closely with eXaminart to develop an OEM CCD camera solution for their Duetto 2 system.



Fig 3 - Toucan OEM with Be window

The Toucan OEM is a custom deep-cooled, deep-depleted CCD30-11 camera with a protruding, offset sensor and a Be window.

- Spectral response (energy) of 2keV - 20keV
- The protruding, offset design enables the sensor to get very close to the object.
- Low noise and low dark current
- USB 2.0 interface
- It is low power, compact and lightweight: 80 x 80 x 90mm and <750g, for portability and ease of use.

Raptor works with many OEMs and instrumentation companies across the world in scientific, surveillance and industrial applications, who need custom designs to meet their exact detection requirements. We develop robust solutions through a detailed project management system. Our quality, reliability, flexibility, and fast delivery make us a very attractive solution for OEMs.

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