HORIBA Scientific

Application Note

Forensics

XGT

XGT14

Gun Shot Residue analysis using X-ray fluorescence micro-analysis

When a gun is fired, in addition to the bullet many other materials exit the barrel of the weapon, and are collectively termed gun shot residue (GSR). GSR is mainly comprised of gunpowder (unburnt and partially burnt gunpowder particles, and carbonaceous soot), ignition primer (typically calcium, lead, barium and antimony complexes), and metals (from the cartridge case, bullet, bullet coating and metal jacket – often containing brass or lead, sometimes with nickel coatings, and lead or antimony from the bullet core).

GSR can travel 1-2 m from the barrel, and so will often be deposited on the victim and perpetrator of the crime – however, at these distances the residues will be very disperse. As the distance between weapon and victim decreases, the GSR will become more concentrated, and within 30 cm will leave visible marking around the wound.

Analysis of GSR and their patterns provide forensic scientists vital information about shooting conditions, and the chemical characteristics of a specific GSR can be used to confirm that a suspect has been in close proximity to a gun being fired, has handled a fired gun, or fired the gun themselves.

This application note uses the elemental micro-analysis capabilities of the XGT-5000 to image GSR on textile, and confirm the composition of single microscopic particles. In addition, a forensic light source and camera (CrimeScope and PrintScope from the HORIBA Scientific) were used to provide additional visual contrast.

Particle Composition

The white light image of GSR on a white fabric sample clearly illustrates the dark particulate matter scattered across the surface (Figure 1). The fluorescence image acquired with the CrimeScope/PrintScope provides additional information – a number of bright yellow spots and larger opaque regions. Comparison shows that these yellow spots do not correlate to the dark features observed in the standard white light image.

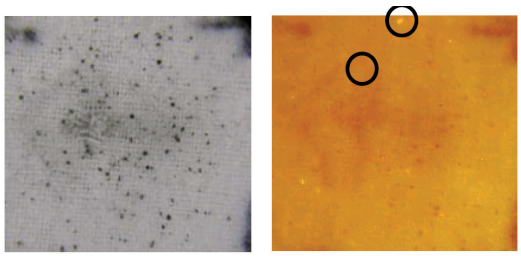

Figure 1: (left) white light image and (right) fluorescence image of gun shot residue on white fabric.

Spectral analysis (Figure 2) of the largest yellow spot and the opaque region (circled in Figure 1) shows that the former is dominated by potassium, calcium and lead. The opaque region shows strong barium content, in addition to lead and other elements.

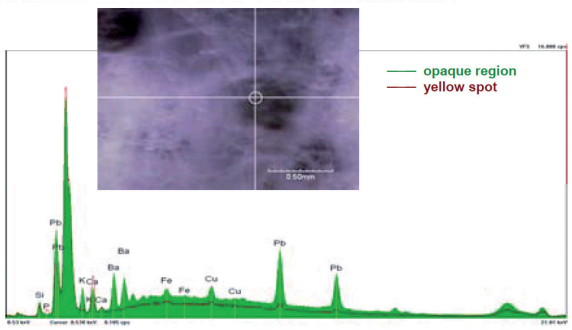

Figure 2: XRF spectra acquired from the yellow spots and opaque region of the gun shot residue sample

GSR imaging

A large area (30 mm x 30 mm) XRF image was acquired using a 100 µm x-ray beam, and provides detailed information on the distribution of relevant elements – in particular, potassium, iron, copper, barium and lead. As Figure 3 displays, potassium containing particles have relatively even distribution across the sample, whilst lead and barium materials are more concentrated around the bullet hole, albeit with the barium less widespread. Only a small number of intense iron and copper containing particles are observed.

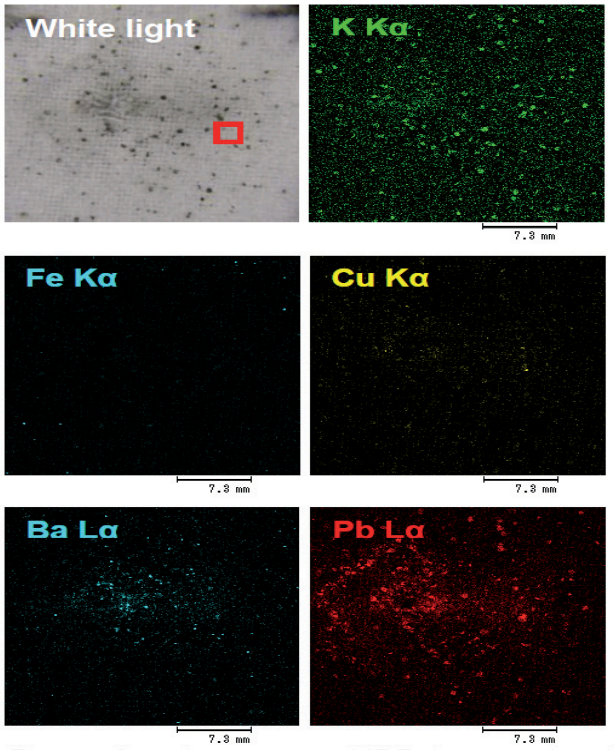

Figure 3: Large area XRF image showing element distribution across the textile. The square in the white light image highlights the region chosen for high resolution imaging, as shown in Figure 4.

A small region of interest (~1 mm^2) containing one of the copper particles was selected for high resolution imaging analysis, using the unique 10 µm x-ray beam available on the XGT-5000. The results (Figure 4) yield detailed images of individual particles, and allow particle size to be accurately determined. For example the large calcium particle is 40 µm, whilst the barium particles range between 20-40 µm. The copper particle can be seen to be significantly larger – approaching 200 µm.

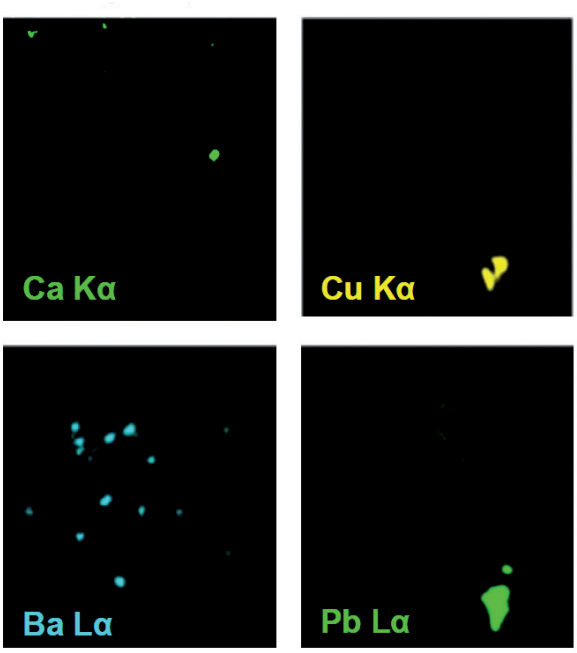

Figure 4: High resolution XRF image (1mm x 1mm) detailing individual particles

Conclusions

GSR composition and patterning are an important information source for forensic scientists investigating violent crime. Micro-XRF analysis allows large area GSR to be imaged, whilst individual particles can be analysed for qualitative and quantitative elemental composition. Traditional forensic light sources and photographic methods have been combined with this versatile technique to locate specific regions of interest.

XGT-5000

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