SPD/AN/098 Issue 1.0 February 2004
Application note from the Spectroscopy Products Division

RENISHAW
apply innovation™

Explosive identification using Raman spectroscopy

Using Renishaw instruments to analyse explosives and gunshot residues

Renishaw's Raman analysis instruments

Renishaw's standard Raman spectrometer, the inVia Raman microscope, is suitable for the vast majority of explosive and gunshot residue samples. However, some samples cannot fit on a microscope stage or cannot easily be brought to a spectrometer. For these situations, Renishaw's RA series analysers present the ideal solution.

The inVia Raman microscope can be supplied with a range of sampling accessories, such as the macro-sampling set or a fibre optic probe, for the analysis of large samples that cannot fit under the microscope or cannot easily be laid flat - such as particles on the sole of a shoe or liquid samples. These accessories facilitate the identification of substances whilst ensuring that sample integrity is maintained, and that vital evidence is not disturbed.

For applications which involve the routine analysis of samples that cannot be brought to a spectrometer, Renishaw's RA series portable analyser systems take the spectrometer to the sample. The system can be mounted in a van or car-boot and uses a fibre optic probe to analyse samples up to 100 m from the spectrometer.

Renishaw's systems can be configured for high-throughput screening applications, using Renishaw's forensic spectral database, and for more involved assessment of manufacturing source or purity.

Renishaw's wide range of sampling accessories can be used to detect and identify explosive particles on almost any surface and through sample bags, vials, etc.

Identification

Renishaw's wide range of Raman systems and accessories can be used to identify many common explosives and associated materials (RDX, Semtex, PETN, ammonium nitrate/sugar, etc.), in the laboratory and in the field.

Example spectra of two common explosives are shown in Figure 1. Trace quantities of explosive substances (down to picograms and micrometre size particles) can be detected non-destructively on almost any surface, including fabrics, metals and paintwork, without the need for sample preparation. Customised options for in-field use (vehicle mounted systems, etc.) and a wide range of accessories make Renishaw's Raman systems among the most versatile available.

Discrimination

Renishaw's proprietary True Raman Imaging™ technology can be used to image traces of explosive within a mixture of innocent substances.

Renishaw's patented True Raman Imaging™ is a radically different technique to traditional point imaging techniques, as it does not use a diffraction grating to produce a series of spectra. Instead it uses tuneable filters to image directly the Raman band of interest.

In Figure 2, the image through a standard microscope shows not even the slightest hint that an explosive is present, even at high magnifications. However, True Raman Imaging™ of a Raman band specific to RDX leads to the image shown (Figure 3). A tiny particle of RDX, no more than 30 µm across, is clearly illuminated in the centre of the image.

Renishaw's inVia Raman microscope

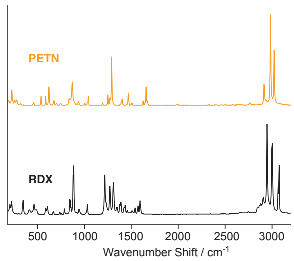

Figure 1
Spectra of the common explosive substances PETN and RDX

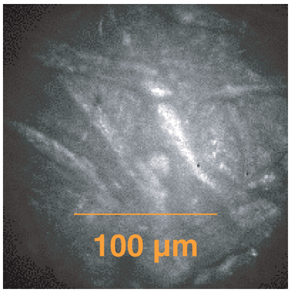

Figure 2
Image of a sample of paper with RDX particle taken using a standard microscope

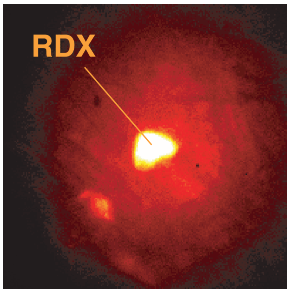

Figure 3
An RDX particle is clearly revealed using True Raman Imaging™

Renishaw plc

Spectroscopy Products Division
Old Town, Wotton-under-Edge,
Gloucestershire GL12 7DW
United Kingdom

T +44 (0) 1453 844302
F +44 (0) 1453 844236
E raman@renishaw.com

www.renishaw.com

RENISHAW
apply innovation™

Gunshot residues

Raman spectroscopy is the ideal tool for the characterisation of gunshot residues (GSRs).

Minute traces of a firearm's discharge can be analysed on almost any surface, reducing the opportunity for contamination or dilution of the sample through inefficient lifting.

GSRs comprise, among other things, various metal oxides, carbonates and nitrates. Renishaw's Raman systems can be used to analyse tiny discharge residues (down to 1 µm across) on almost any surface. In addition, Renishaw's forensic database's search facility makes the identification of many common compounds quick and easy.

The spectra in Figure 4 were taken from three different gunshot residue particles. Each exhibits features associated with barium oxide (BaO) and barium carbonate ($BaCO_3$).

Renishaw gratefully acknowledge Prof. J Yarwood, Sheffield Hallam University, for the gunshot residue data shown.

Structural and chemical analyser for SEMs

One of the most recent additions to Renishaw's range of spectroscopy tools, the structural and chemical analyser, allows integrated Raman analysis inside a scanning electron microscope (SEM). All investigative techniques coupled to the SEM, such as EDS, BS, SEI, etc. can analyse the same spot on the sample, allowing identification of microscopic particles that may be indiscernible using optical microscopy.

Raman spectroscopy has a spatial resolution comparable to energy dispersive x-ray analysis (EDS). A laser spot, of the order of a micrometre diameter, can be focused onto or into the sample, and spectra collected from the sampled volume. Provided light can reach the sample, the Raman effect is unaffected by the operating environment, so the technique works equally well under environmental, low, high, or ultra-high vacuum SEM conditions.

Figure 5 shows a crystal mixture on a SEM stub; samples like this might be prepared by forensic scientists attempting to ascertain the nature of suspicious material. Due to the high depth of field of the SEM image, it is immediately apparent that there are two classes of crystal present - large predominantly cubic types, and smaller triangular ones.

EDS is available on the majority of SEMs and is the routine choice for analysis of unknown samples. For the two crystal types shown, the EDS spectra (Figures 6 and 7) show one crystal type contains carbon and oxygen, the other oxygen, sodium, and chlorine. However, these elemental analyses do not identify the crystals conclusively.

Raman analysis using the SCA generates the spectra shown in Figure 8. These can be matched against reference spectra, such as those in Renishaw's Raman spectral databases, to show that the crystals are sucrose and sodium chlorate - sugar and weed-killer - common constituents of home-made explosives.

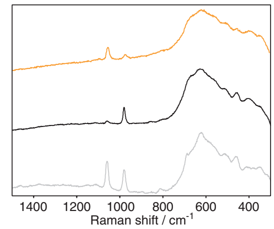

Figure 4
Spectra of three GSRs

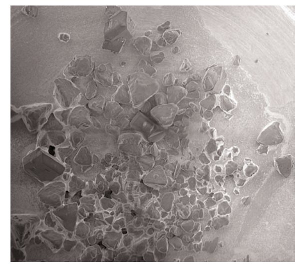

Figure 5
SEM image of crystal mixture

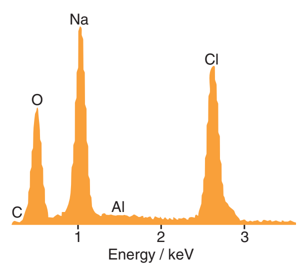

Figure 6
ED spectrum showing sodium, oxygen and chlorine

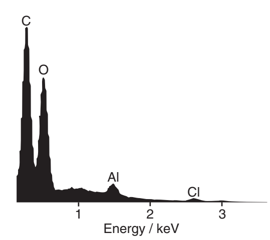

Figure 7
ED spectrum showing carbon and oxygen

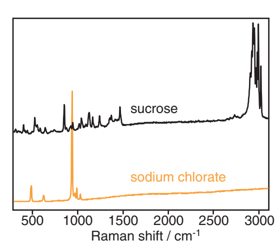

Figure 8
Raman spectrum identifying sucrose and NaOCl