

Drug detection using Raman spectroscopy

Simple, rapid identification and characterisation of illicit substances

What is a Raman spectrum?

Raman spectroscopy uses a laser to probe the vibrational energy levels of a molecule or crystal. The Raman spectrum gives a set of peaks that correspond to the characteristic vibrational frequencies of the material. These can be used as a 'fingerprint' to identify the substance by searching a database of reference spectra.

Raman spectroscopy is similar to infrared (IR) or FT-IR) spectroscopy. However, due to the different 'selection rules' governing Raman activity, the two techniques are highly complementary. Figure 1 shows the FT-IR and Raman spectra of PETN, a common component in explosives. Bands related to vibrations which are both Raman and IR active have been highlighted. Notice the extra information contained in the Raman spectrum of PETN.

Raman spectroscopy has many advantages over infrared, including:

- it is non-destructive and non-contacting
- it requires no sample preparation - evidence is preserved
- samples can be analysed through plastic sample bags or glass bottles, on almost any surface, and in aqueous solution
- particles as small as 1 μm to 2 μm across can be studied routinely
- Low frequency shifts of inorganic molecules are easily accessible - allowing study of paint chips, etc.

Renishaw's Raman analysis instruments

Renishaw's standard Raman spectrometer, the inVia Raman microscope, is suitable for the vast majority of samples. However, some samples cannot fit on the microscope stage or cannot easily be brought to the 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 drugs 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 the 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 both 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 drugs; on almost any surface; through sample bags, vials, etc.; up to 100 m from the spectrometer.

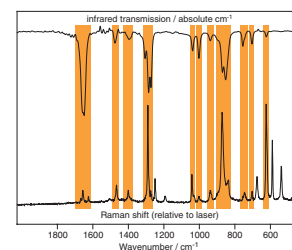


Figure 1
FT-IR and Raman spectra of PETN



Renishaw's inVia Raman microscope, with optional eyepieces



Renishaw's RA100 portable Raman analyser

Identification

Renishaw's forensic analyser systems can be used to identify common narcotics as well as to characterise cutting agents and, in many cases, even manufacturing source.

Some examples of the high quality spectra observed with Renishaw's Raman systems are shown in Figures 3 and 4. These spectra illustrate the ease with which Raman spectroscopy can differentiate between compounds, even if they have very similar structures (Figure 2). For example, in the methamphetamine spectra below, the methyl substituent of the amine leads to a peak at 2459 cm^{-1} , characteristic of a secondary amine. This peak is not observed in the spectrum of amphetamine, which only contains a primary amine. Similarly, the Raman spectrum of heroin (diacetylmorphine) contains an ester peak at 1740 cm^{-1} , while the spectrum of morphine does not.

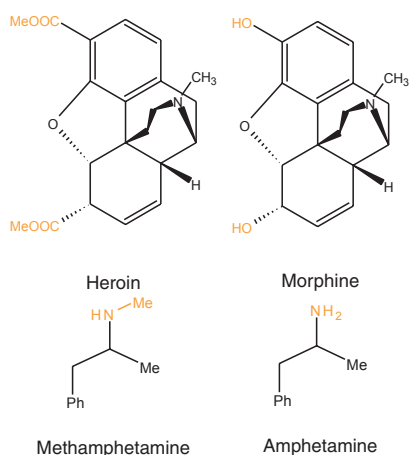


Figure 2
Structures of two pairs of similar drugs.
Structural differences are highlighted in orange.

Acknowledgements

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- Fig. 1 Prof. DN Batchelder, University of Leeds
Figs. 2/3 Profs. Zhao JT and Zhang PX, Yunnan Polytechnic University, PR China

Discrimination

Renishaw's forensic analyser can be supplied with proprietary True Raman Imaging™ technology. The imaging filters are tuned to the Raman band of interest, under software control, and then generate a 2D image of component distribution.

Figure 5 shows a white light image of a mixture of cocaine hydrochloride and sugar. Very little detail can be seen and discrimination is impossible, even at high magnification. Figure 6 shows the combined image of the 1601 cm^{-1} and 1713 cm^{-1} Raman bands of cocaine hydrochloride, recorded using True Raman Imaging™. Bright regions of the image show the presence of cocaine, making discrimination of the drug particles from the cutting agent a trivial exercise.

Raman systems for forensic applications

Whatever your forensic science analytical requirements, Renishaw's varied range of Raman instruments should be ideally suited to meet your needs. However, if you have special requirements, please contact Renishaw's Spectroscopy Products Division. Our dedicated Special Products team have extensive experience designing custom instruments and components for niche applications.

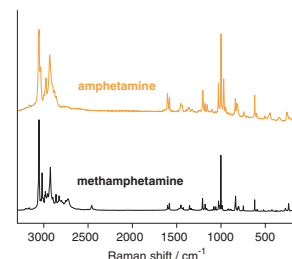


Figure 3
Raman spectra showing clear and unambiguous discrimination of common amphetamines

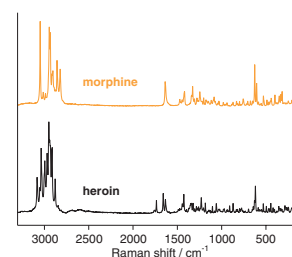


Figure 4
Raman spectra of heroin and morphine

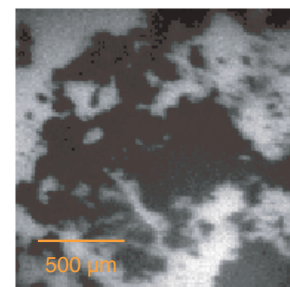


Figure 5
White light image of sugar and cocaine hydrochloride

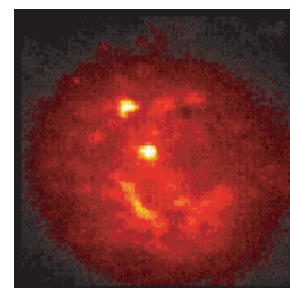


Figure 6
True Raman Image of the sugar/cocaine hydrochloride.

Renishaw is continually improving its products and reserves the right to change specifications without notice.