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Why Transmission Raman ?

Ref: HES-ISI-RP-0013 01

INTRODUCTION

Raman spectroscopy is a common tool used in a variety of industries for identifying the composition of a sample or gas, and is now being more widely used for the quality assurance of their manufacturing processes. The majority of these measurements are made in a point sampling manner, however, this can lead to errors in the measurement. One solution to this issue is to perform Transmission Raman measurements to provide a true bulk measurement of the sample being targeted.

Pharmaceuticals are one of the largest global industries worth ~US$800 billion and is expected to grow at a rate of 5% pa. In addition to being the UK's highest added-value industry, there is also a lot of investment in Pharmaceutical research (€27 billionin Europe alone in 2011) and the sector employs more than 650,000 people. Counterfeit products are estimated by Sanofi to be 10% of the market and is a major problem that requires new and quicker methods of detection to ensure consumer safety and protect the huge investment made by this industry.

Transmission Raman is of particular interest to quality assurance and counterfeit detection applications. The current market for Raman measurements is £200 million with the pharmaceutical market being around £60 million. When new flexible and improved detection methods are available, as proposed, the market for Transmission Raman measurements will grow significantly.

A typical illumination setup for a Transmission Raman measurment is shown in Figure *1* the light exiting the sample is often a very weak signaland thus every photon is important. The laser pentrates the sample causing Raman to be excited, however when the light exits, the Raman photons scatter from a larger area > 2 mm in diameter and have a signifcant target etendue. The spectrometer is required to match this etendue in order for light not to be lost.

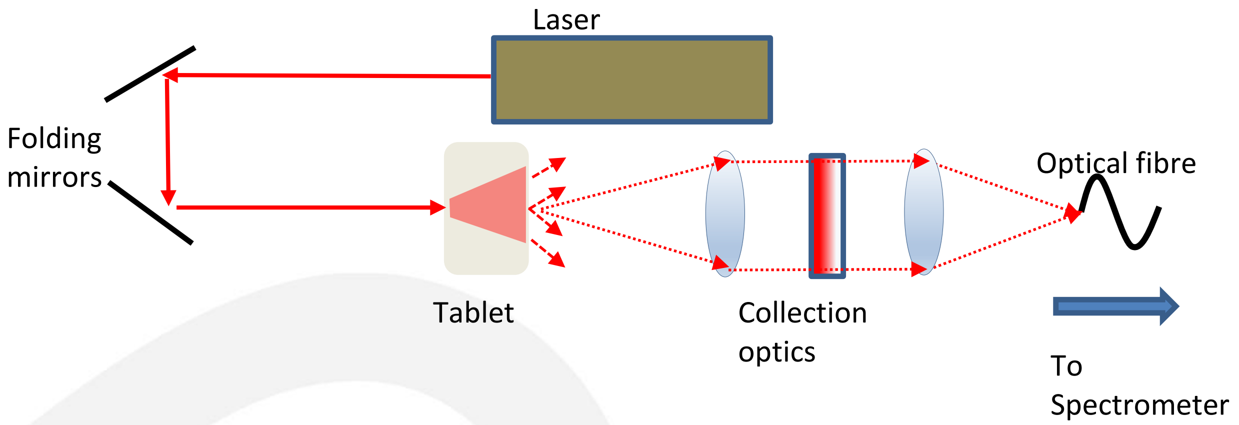

Figure 1- Typical Transmission Raman arrangement.

The HES range of spectrometers developed by IS-Instruments Ltd offers 100 times greater etendue than traditional Czerny Turner devices, they have no slit, can be coupled to a 1 - 1.5mm diameter 0.22NA fibre with no loss of light, and achieve execellent resolution . These features make these devices ideal for Transmission Raman, dramatically simplifying a potential transmission Raman Quality Control (QC) instrument all for a relatively low-cost (< £40K).

THE EXPERIMENT

THE SPECTROMETER

For these experiments a bespoke IR version for the HES 2000 spectrometer was used, the specifications of the spectrometer and the illuminating laser are given in Table 1. Whilst operation at the IR wavelengths reduces fluorescent signals from the sample, detector noise can be significant in comparison with measurements made using a 785 nm laser. The laser used had to be passed through two clean up clean filters, due to its spectral width. Therefore ~ 70 mW of light was intercepted by the sample. For the experiments the spectrometer was fibre coupled to a 2 mm diameter fibre with a 0.22 Na.

Table 1- Raman spectrometer specifications

Parameter	Specifications	Notes
Illuminating wavelength	1064 nm	
Laser power at Tablet	70 mW	Laser provided 100 mW, but had to be passed through two clean up filters.
Spectral range	30 - 1850 cm^{-1}	
Spectral resolution	< 8 cm^{-1}	
Fibre input aperture	Up to 3 mm diameter	For experiments a 2 mm core fibre was used with a 0.22 Na (a 50 % insertion loss was observed at the collection fibre)
Detector type	Andor IDus	Cooled to – 70 C
Number of pixels	512	
Pitch	25 × 500 µm	

THE SAMPLE

The selected sample was an ibuprofen tablet purchased from a major UK supermarket, an image of the sample is shown in Figure 2.

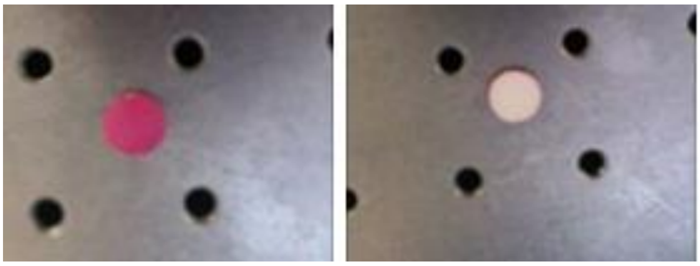

Figure 2- Sample Ibuprofen Tablet

One side the sample has been grounded down to remove the sugar coating from the tablet. Measurements of the Raman response were made in a backscatter configuration from both surfaces, as well as in a Transmission Raman setup.

THE RESULTS

Figure *3* shows the Raman spectra from the sample when in a Transmission configuration, the observation was made with an integration time of 10 seconds, to provide a clean response (although the spectrum was clear within 5 seconds). The spectrum shows a broad complex feature, from 230 – 600 cm^{-1}, and from 600 – 1830 cm^{-1} where a typical Ibuprofen profile is measured.

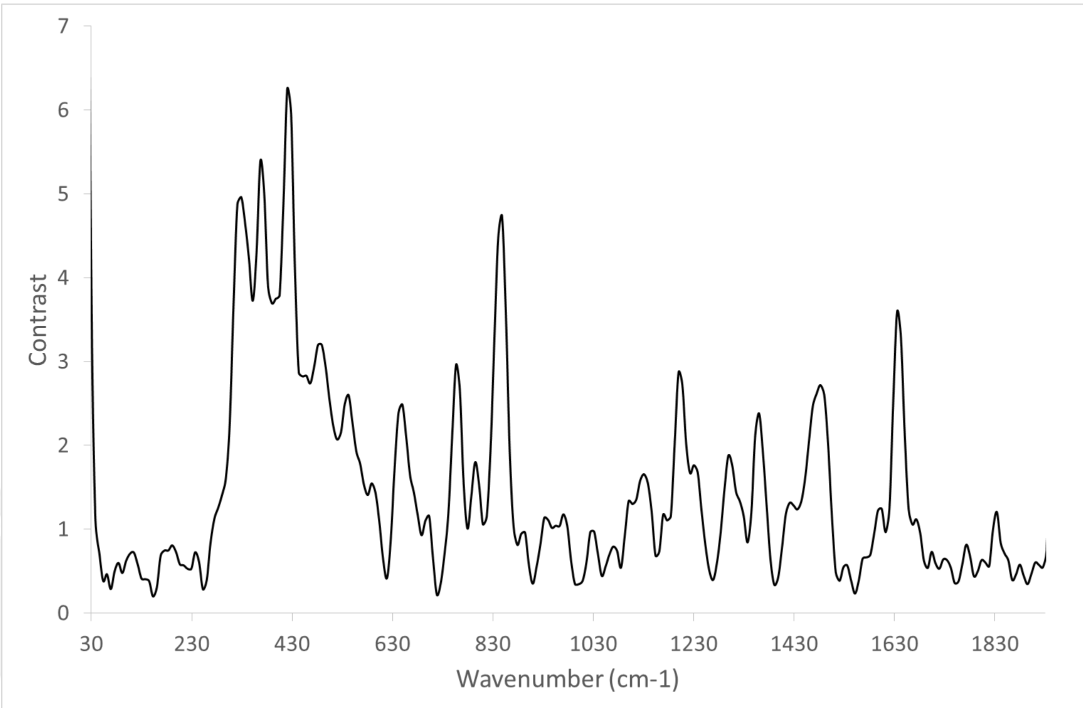

Figure 3- Transmission Raman Spectrum of Ibuprofen (integration time 10 seconds)

The backscatter Raman response from the white face of the tablet is given in Figure 4, where the integration time was 3 seconds. There are clear difference between the two measurements, in particular, the broad feature from 230 – 600 cm^{-1} is considerably reduced, indicating that this feature is the response of the coated surface.

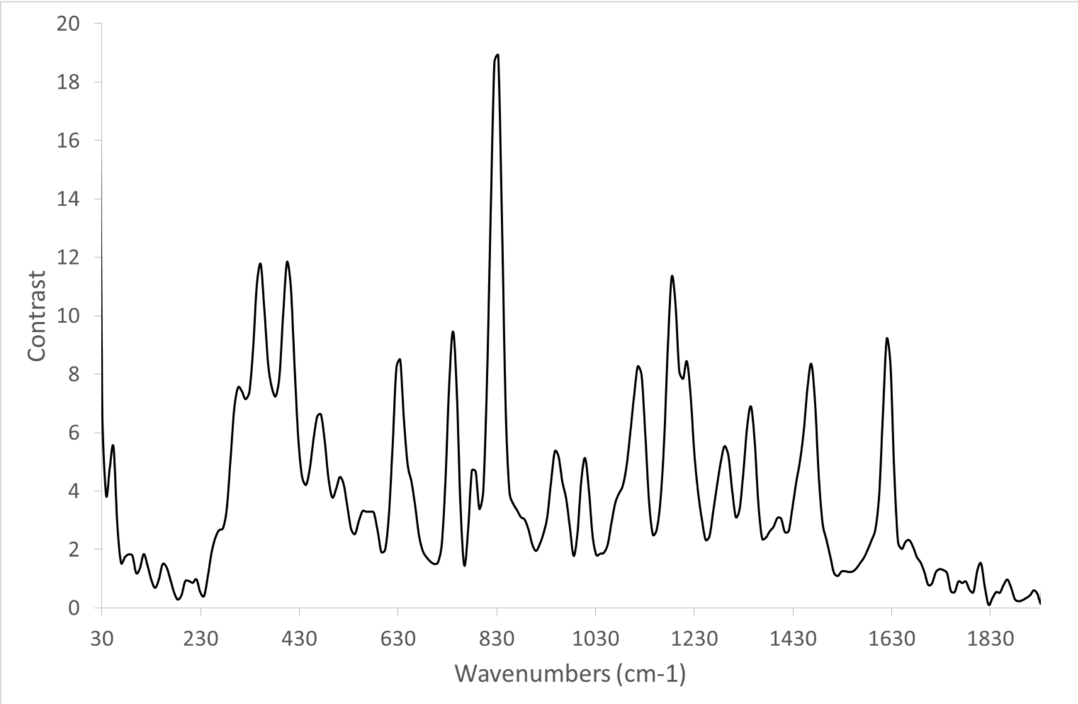

Figure 4 Backscatter Raman measurement white side of the sample intercepted by the laser

The tablet was then rotated and the response from the pink surface was measured in Figure 5. The spectral response is now significantly different from the previous two observations; there is now a strong under lying broadband feature from 230- 1000 cm^{-1}, a typical fluorescent feature generated by the tablets sugar coating.

If this tablet was measured in a factory or the filed this would be the response observed.

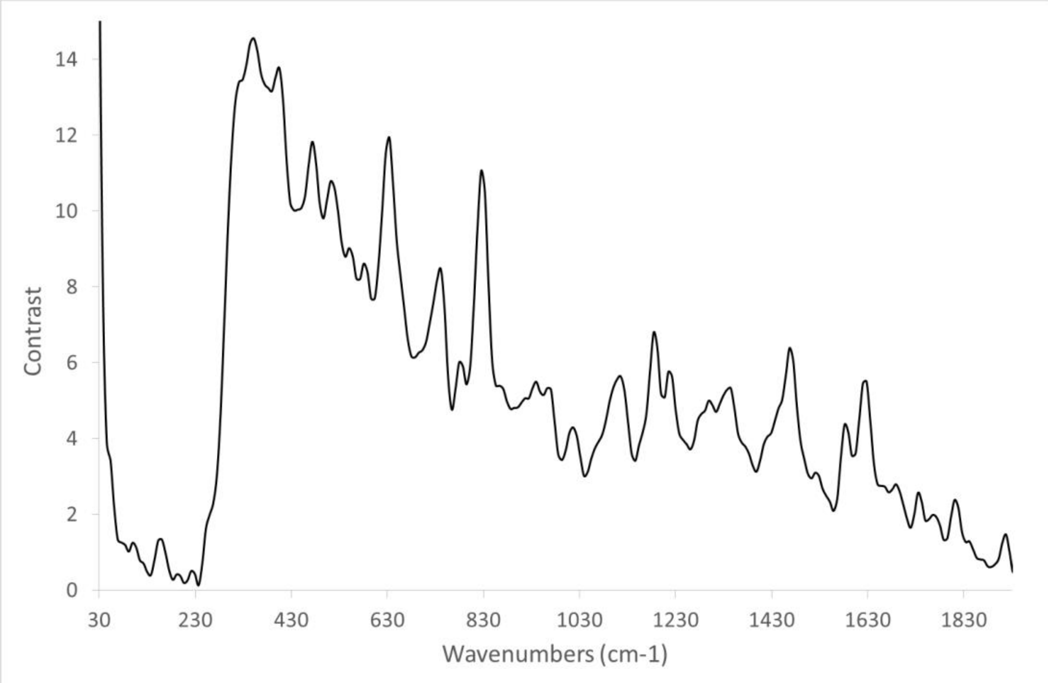

Figure 5- Backscatter Raman measurement pink side of the sample intercepted by the laser

Figure 6 shows all three Raman measurements from the tablet on the same plot. The transmission Raman clearly provides a response from the tablet and shows the advantages of using this technique.

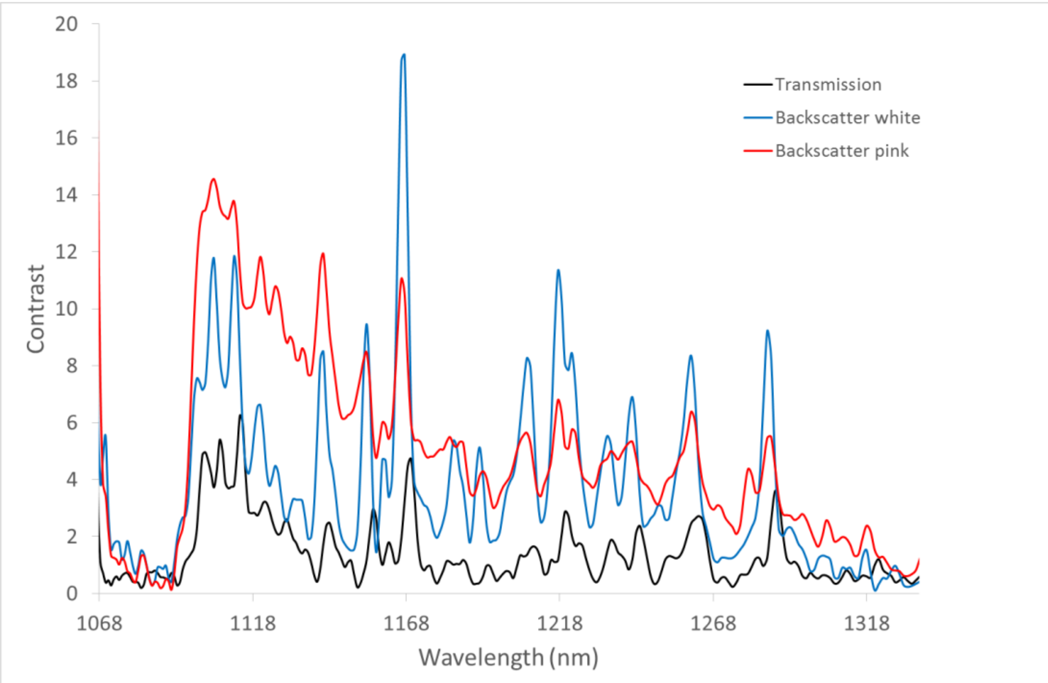

Figure 6- Raman spectra of Ibuprofen in all configurations, Black line = Transmission, Red line = Pink side backscatter, Blue Line = white side backscatter

CONCLUSIONS

The ability of Transmission Raman to make bulk measurements of a sample has been demonstrated with an IR HES 2000 spectrometer. An Ibuprofen tablet has been measured from both sides and the Raman response clearly shows a bias to the top surface of the sample. In this case, the coated surface shows a fluorescent-type response which potentially masks the Raman signal.

By observing the tablet in a Transmission configuration, the response from the whole tablet is observed and thereby reduces the dominance of the coated surface. This measurement is possible with short integrations time due to the etenude advantage provided by the HES 2000 spectrometer.

For more information

www.is-instruments.com