



Application Note 410000006-B

Spectroscopie Raman à basse fréquence

Raman spectroscopy is an analytical tool that permits measurement of the molecular structure and identification of materials based on the rotational and vibrational modes of a molecule. Most commercial laboratory Raman systems cover the fingerprint spectral region ranging from 200–3400 cm^{-1} .

The B&W Tek i-Raman Plus BAC102 probe can access

lower-frequency modes down to 65 cm^{-1} , providing a cost-effective solution for fuller range measurements. Access to lower-frequency regions provides key information for applications in protein characterization [1], polymorph detection and identification [2], along with material phase and structure determination.

INTRODUCTION

The low-frequency region augments the information content from the fingerprint region of the Raman spectrum and broadens possible molecular

applications, such as detection of hydrogen bonds. The result is increased detection sensitivity and differentiation of very similar materials.

Amino acids

Raman spectroscopy is a modern way to study the structure and conformation of the building blocks of proteins—amino acids. Specifically, the vibrational information content in a Raman spectrum can help with interpretation of molecular interactions and biological processes [3].

Unlike many substances that do not exhibit peaks below $\sim 400\text{ cm}^{-1}$, the low-frequency portion of the

Raman spectrum is a necessary source of information for a comprehensive study of amino acids. This is obvious in the full Raman spectrum of L-asparagine, from $65\text{--}3200\text{ cm}^{-1}$ (Figure 1).

Figure 1 shows both the fingerprint region (blue) as well as the low-frequency Raman region (red) for L-asparagine; note the three dominant bands below 200 cm^{-1} .

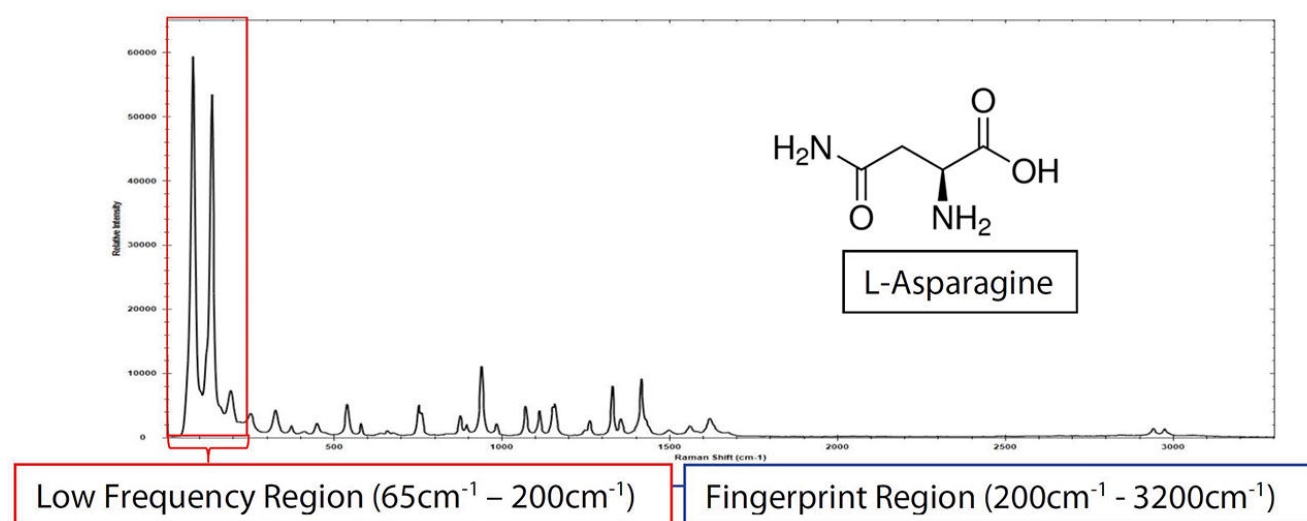


Figure 1. i-Raman Plus and a BAC102 E-grade probe were used to collect the low-frequency spectra of L-asparagine with a total integration time of 1.2 s.

EXPERIMENT

i-Raman Plus 785S, B&W Tek's laboratory Raman spectrometer that utilizes patented CleanLaze®, was used in this application. This instrument features 785 nm laser excitation with a linewidth of less than 0.2 nm and maximum power output of 300 mW.

i-Raman Plus is equipped with a sensitive, TE-cooled, back-thinned CCD. A BAC102 E-grade probe, utilizing

proprietary technology, supports data collection within a full spectral range of $65\text{--}33500\text{ cm}^{-1}$ with a spectral resolution of 4.5 cm^{-1} .

Raman spectra were collected at room temperature using 300 mW laser power with integration times that ranged from 100 milliseconds to 10 seconds (Table 1).

Table 1. Experimental parameters.

Equipment	Acquisition settings	
i-Raman Plus 785S	Laser Power	300 mW
BAC102 probe	Integration time	1.2 s
BWSpec software	Averages	1

Determining the structural form of active pharmaceutical ingredients (APIs) is a primary concern for the pharmaceutical industry. This is especially true during drug development, manufacturing, and quality control.

APIs exhibit polymorphism—identical chemical composition but different solid-state structures. Polymorphs may affect bioavailability and therapeutic

index. The efficacy of a drug can be compromised if the wrong form is used [2]. Pseudo-polymorphs include solvents suspended in a lattice structure.

Figure 2 is an example of the pseudo-polymorph D-glucose, demonstrating the ability of the E-grade probe to detect differences between the monohydrate and anhydrous forms at frequencies below 200 cm^{-1} .

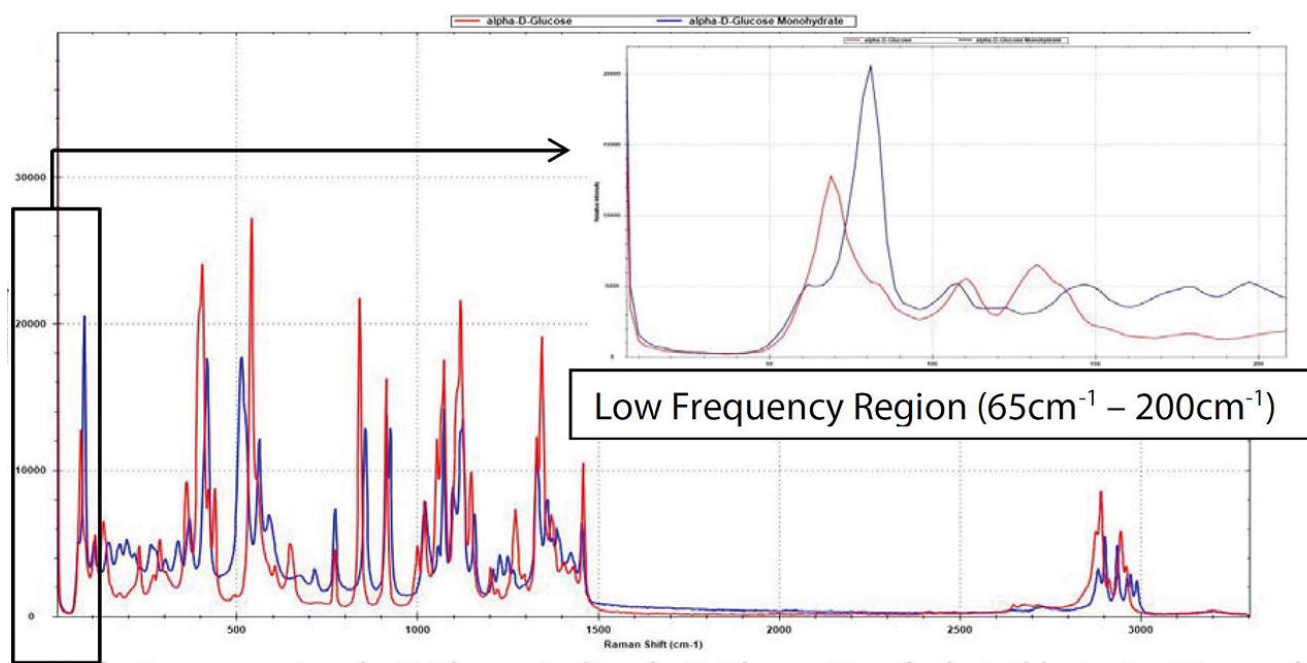


Figure 2. Raman spectra of α -D-glucose (red) and α -D-glucose monohydrate (blue), taken with 10 s integration time. Note the significant difference between the two pseudo-polymorphs within the low-frequency range (see inlay).

RESULTS: MONITORING PHASE CHANGE

Exceptional specificity is required to monitor phase changes like crystallization in chemical processes. The low-frequency E-grade probe can monitor such phase changes, as demonstrated for sulfur (Figure 3).

Solid α -sulfur was deposited onto an aluminum tray and heated with a hot plate while the Raman spectra were collected with an E-grade probe and i-Raman Plus, using 100% laser power (~300 mW) and 0.1 s

integration time for both the solid and liquid phase.

After the sample was heated above its melting point at 115.2 °C, the low-frequency peak at 83.6 cm^{-1} broadened and shifted, indicating the change from the α - to the λ -form. Note that there are no observable changes within the fingerprint region (Figure 3).

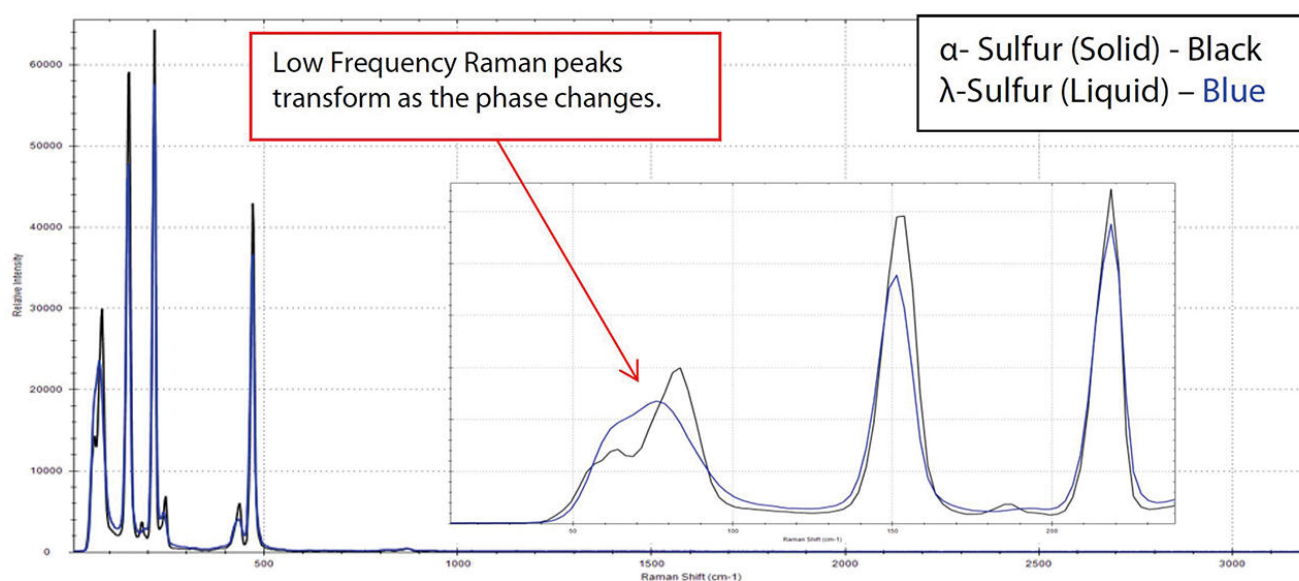


Figure 3. Raman spectra of sulfur transitioning from the α -crystalline form to the λ -liquid form, taken with 0.1 s integration time. Note significant broadening in the peaks located in the low-frequency region (see inset).

CONCLUSION

i-Raman Plus 785S Raman spectrometer, coupled with the low-frequency E-grade probe, can be a valuable tool for applications requiring low-frequency detection down to 65 cm^{-1} . The ability to characterize polymorphs and solvated forms supports manufacturing and formulation processes in the

pharmaceutical and biological industries.

Along with protein, polymorph, and phase characterization, low-frequency Raman spectroscopy can also be used to study semiconductor lattices [4], carbon nanotubes [5], solar cells, and an assortment of minerals, pigments and gemstones.

REFERENCES

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CONFIGURATION



Spectromètre Raman portable i-Raman Plus 785S

L'i-Raman® Plus - 785S appartient à notre série primée de spectromètres Raman portables « i-Raman », équipée de notre technologie de spectrométrie intelligente et innovante. Faisant appel à un détecteur à barrette CCD à haute efficacité quantique, avec refroidissement thermoélectrique et une gamme dynamique élevée, ce spectromètre Raman portable fournit des performances exceptionnelles avec un bruit réduit, même avec un temps d'intégration atteignant 30 minutes. Ainsi, les signaux Raman faibles peuvent aussi être mesurés.

Le i-Raman Plus 785S offre la combinaison exclusive d'une large gamme spectrale et d'une haute résolution avec des configurations autorisant des mesures de 65 cm^{-1} à 3350 cm^{-1} . Le faible encombrement et la légèreté de structure de ce système peu énergivore lui permettent d'effectuer partout des analyses Raman de qualité recherche. Équipé d'une sonde à fibre optique pour faciliter l'échantillonnage, l'i-Raman Plus peut être utilisé avec un support de cuvette, un microscope vidéo, une table de translation XYZ avec support de sonde ainsi qu'avec notre logiciel d'analyse à variantes multiples BWIQ® et le logiciel d'identification BWID®. Avec le i-Raman Plus, vous avez une solution Raman pérenne de haute fidélité pour l'analyse qualitative et quantitative.



Extension de sonde Raman avec déclencheur (785 nm)

Module avec sonde à fibre optique Raman de qualité laboratoire pour démarrage Cut-on à partir de 65 cm^{-1} , avec déclencheur manuel, fibre $105 \mu\text{m}$ de diamètre, ON 0,22 pour excitation à 785 nm, fibre $200 \mu\text{m}$ de diamètre, ON 0,22 pour détection Raman. Densité optique > 6 , longueur 1,5 m avec connecteur SMA905 côté spectromètre et connecteur FC/PC côté laser. Fenêtre en verre de quartz scellée par un adhésif pour échantillonnage sans contact. Distance de travail 5,4 mm. Ne convient pas à l'immersion.