High Throughput Large Spot Adaptor

Conventional Raman typically has a very small sampling area with a high power density (PD) at the laser focal point on the sample, which means that only a limited portion of a sample is measured, and the result tends to be irreproducible for heterogeneous sample. The high power density may also cause samples to heat up or burn.

The large spot adaptor (LSA) for B&W Tek's handheld Raman products, featuring a much larger sampling area of 4.5 mm in diameter, is designed to overcome these issues.

The conservation of throughput (aka Etendue) of optics dictates that as the sampling area increases, the solid angle of collection decreases in the same proportion. However, the collected Raman photon is proportional to the product of Etendue and excitation power density. As the excitation power density is also reduced by the same proportion, this would result in a net loss of sensitivity. The LSA uses a patented technique to compensate this loss by means of a resonance cavity[1] and its effect on sensitivity and sampling volume is illustrated in Figure 1. The sample is sodium benzoate powder contained in a white polyethylene bottle. When the probe is focused at the surface of the sample, as in 1(a), the signal is strong, but comes primarily from the surface, i.e. polyethylene; When the probe is defocused as in 1(b), the signal is very weak, but due to the increased sampling depth, the strength of sodium benzoate peaks (indicated by the green arrows) relative to the bottle wall is increased; Using the LSA, as illustrated in 1(c), the signal is enhanced significantly over that of 1(b), while the large sampling area and depth is maintained.

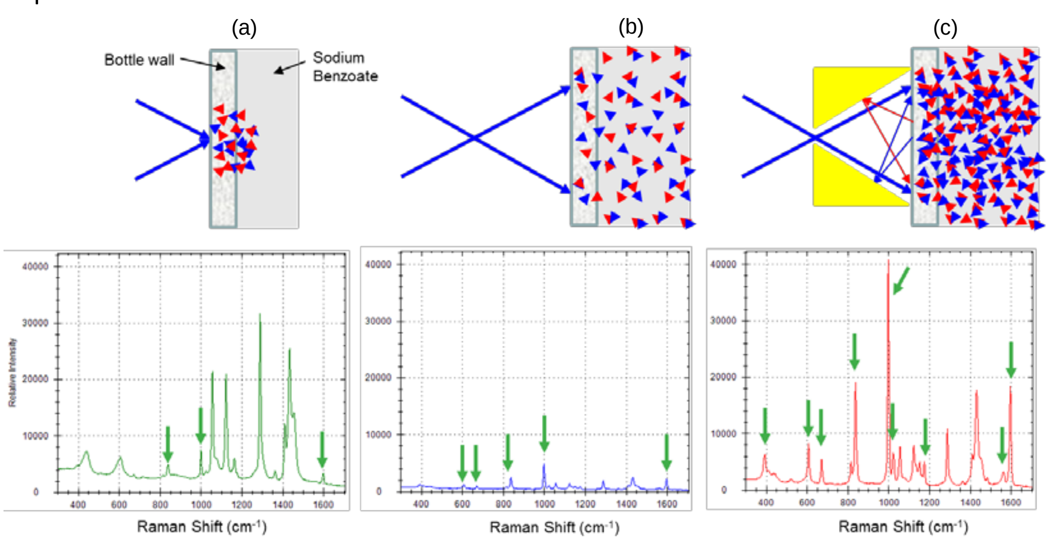

Figure 1

The large spot adaptor (LSA) with large sampling area has the advantage of preventing sample damage by reducing the power density, as well as improving measurement accuracy by eliminating heterogeneous effect from the sample. In addition, the design enhances the relative intensity of the signal from the deeper layers, thereby increasing the effective sampling depth. Coated tablets can be measured using the LSA which penetrates the coating layer and measures the Raman spectrum of the underlying tablet. And because the power density of the system is lower than the highly focused signal used in conventional Raman, even colored tablet coatings and dark samples can be measured without laser burning of the surface.

<u>Example 1</u>

Excedrin migraine tablet contain 3 active ingredients: aspirin, acetaminophen, caffeine, and other excipients. With conventional Raman where the laser spot can be in tens of microns, spectra measured at random locations on the tablet and their hit quality indices showed large variations, shown in Figures 2(a) and 2(b). With LSA, the inconsistencies are greatly reduced, as illustrated in Figures 2(c) and 2(d).

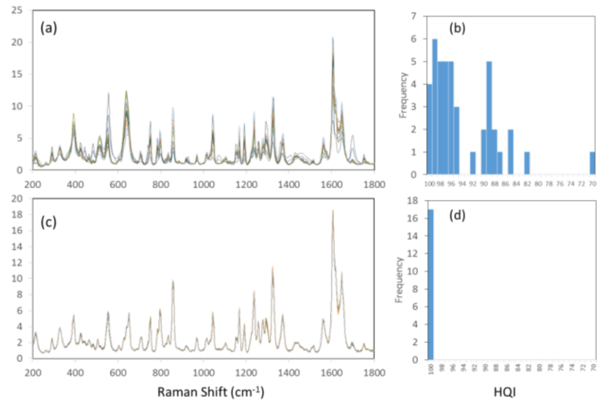

Figure 2

<u>Example 2</u>

Even pure samples can present variability due to Raman polarization effect, if the sample is in the form of crystals of sizes similar to or larger than the sampling area. Xylitol is a sugar alcohol that has a crystalline, granular structure. Similar to heterogeneous samples, spectra of xylitol measured at random locations and their hit quality index showed large variations, as shown in Figures 3(a) and 3(b). With LSA, the inconsistencies are greatly reduced, as illustrated in Figures 3(c) and 3(d).

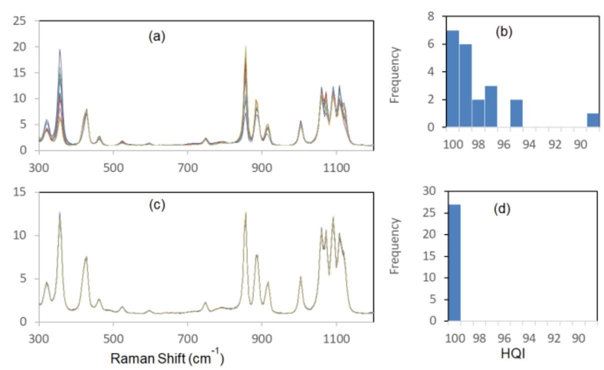

Figure 3

In conclusion, consider the use of the large spot adapter against non-transparent samples that are in powder format, in dark colors, or with inhomogeneity.

This adapter is not recommended for use with clear liquid samples.

Reference

1. Jun Zhao, Xin J. Zhou. "Methods and devices for measuring Raman scattering of a sample". US patent 10,113,969 B2. 2018.

