Spectral Imaging Capabilities of Hyperspec™ Imaging Technology

In Pharmaceutical Operations

Hyperspectral imaging technology is an established chemical sensing and imaging technology that allows for the spectroscopic analysis of any particular sample or point within a scene of interest. From its introduction during the mid-1980s as a means to conduct remote sensing experiments to its success as a military and defense sensor technology, hyperspectral imaging is poised for rapid adoption in commercial markets involving complex manufacturing of chemical materials and products.

Headwall Photonics has been at the forefront of hyperspectral imaging since 1994 with continuous investment to advance the capabilities of its sensor products. With its patented fourth generation product designs, the company has established a worldwide reputation for exceptional imaging performance. Two performance attributes which are critical to Headwall's success have been the achievement of high spectral and spatial resolution coupled with exceptional photometric accuracy.

With a focus on OEM partners, Headwall Photonics is designing advanced spectral imaging systems for new hyperspectral and Raman application areas which demand high levels of spectral and spatial resolution, high throughput efficiency, and dynamic accuracy performance

Sample Pharmaceutical Dataset

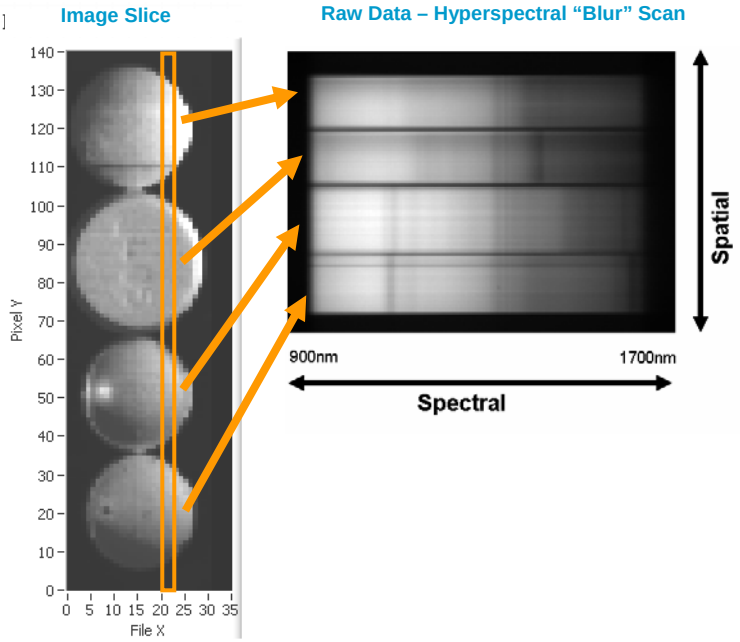
To demonstrate the value of hyperspectral imaging technology within a pharmaceutical operation, application engineers from Headwall Photonics scanned similar tablets comprised of the following four generic drug compounds:

Aspirin
Acetaminophen
Vitamin C
Vitamin D

These four compounds were scanned simultaneously with one of Headwall's Hyperspec-NIR™ imaging sensors utilizing a moving linear stage. Samples were scanned in both powder and tablet form as shown in the following photograph and the corresponding image slices were "stitched" together.

One obvious advantage of Headwall's Hyperspec™ imaging is the ability to scan multiple tablets simultaneously as tablets are moving across a process line. The number of tablets that can be scanned is based on required field of view (FOV) and the spectral/spatial resolution required (IFOV, instantaneous field of view). These parameters are application-specific and can be modeled to identify specific sensor components required to achieve the required performance.

The following photograph represents a *single* image slice of four generic tablets taken during a process line scan experiment. The corresponding "blur" scan in the photograph represents a magnified slice of the field of view as the tablets move across the process line; the data content comprises the spectral and spatial information which will used to build the hyperspectral datacube from which spectral imaging data will be rendered and analyzed.



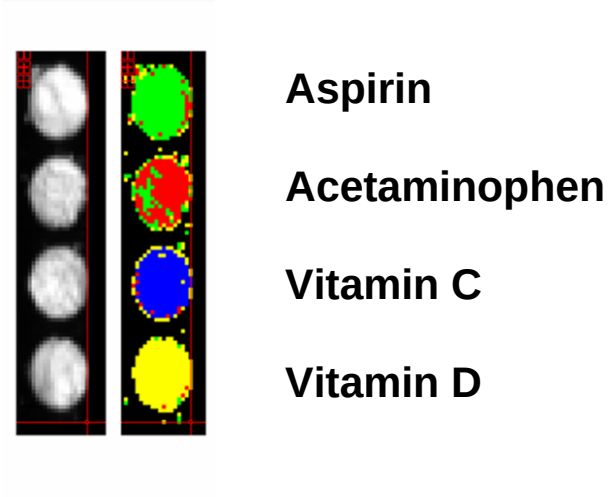
A unique advantage of Headwall's hyperspectral sensor technology is analytical information of interest can be displayed real-time while the entire analytical dataset (spectral and spatial) is captured and can be stored for further analysis at a later time. Applications involving NIR chemical imaging such as spray dry dispersion are very well suited to techniques such as hyperspectral imaging.

Hyperspectral imaging analysis yields the following results:

- Rendered view of the scene of interest based on chemical spectra
- Spectral wavelengths of interest based on intensity thresholds
- Chemical spectra of any particular point in the field of view

1) Rendered view of the scene of interest based on chemical spectra

Compounds and chemical formulations comprised of different spectral signatures can be color-coded based on user-defined parameters. For example, with spray dry dispersion techniques, the presence (or absence) of multiple compounds or lack of spectral homogeneity in a sample or pill of interest can be identified as in the following hyperspectral image.



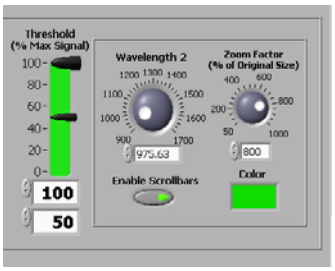
2) Spectral wavelengths of interest based on intensity thresholds

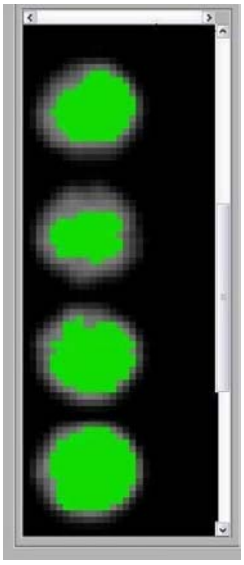
Given the amount of data generated for the hyperspectral datacube, wavelength intensity thresholds can be established which are specific to the presence or absence of target compounds of interest. These parameters are application-dependent and the spectral "triggers" can be established and set by the user in real-time.

The following spectral wavelength “fingerprints” were evident based on the sample intensity triggers established:

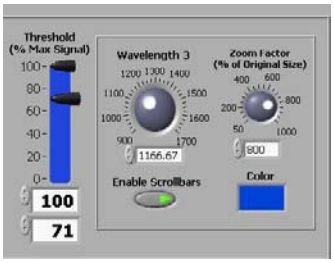
Wavelength Intensity Maps

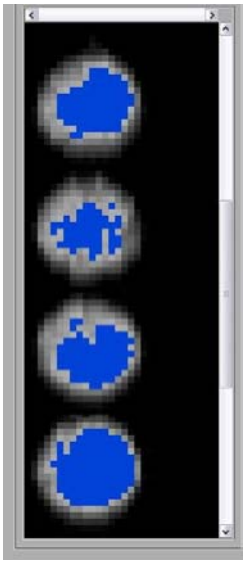
975 nanometers



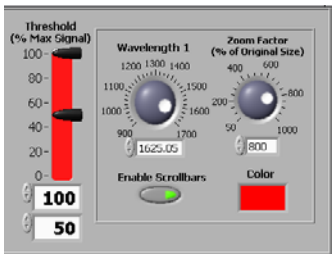


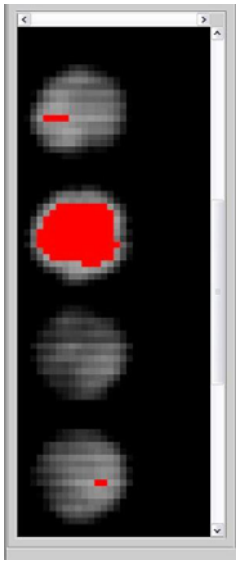
1166 nanometers





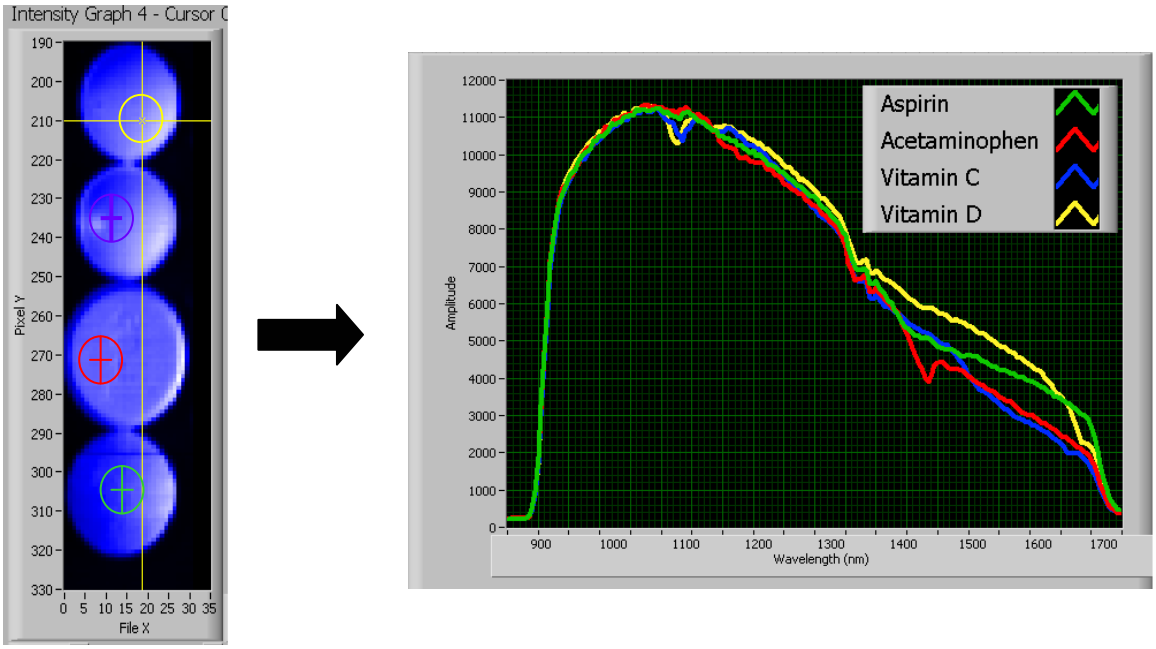
1625 nanometers





3) Chemical spectra of any particular point in the field of view

For any pixel or spatial position within the field of view, the corresponding chemical spectrum is obtained and can be graphed as required. For example, the following spectral imaging results were generated as a result of the scanned image of generic tablet compounds investigated:



For the purposes of this illustration, all of the corresponding spectra for each of the tablets are shown. Given the specific application or analytical need, specific or relevant spectral data can be rendered in the required level of detail or wavelength resolution. For example, not all hyperspectral data need to be displayed; in some cases, it may be appropriate only to display spectral bands of interest to the researcher or manufacturing engineer.

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