LCMS-2020 - Reduces Limitations of HPLC Analysis and UFLC Analysis

Technical Report vol.19

1. Need for Ultra-Fast Analysis

One of the biggest issues for HPLC is faster analysis, and this requirement is being addressed with the ultra fast LC “Prominence UFLC”. The ultimate in speed, superb repeatability and enhanced performance provided by this instrument have permitted penetration of UFLC analysis into many different fields.

While there are different definitions of ultra fast LC, it can generally be considered to be “LC which is an order of magnitude faster than conventional LC”. Analyses which previously took 30 minutes to complete can be accomplished in under 3 minutes, or about one-tenth the time. Along with its breathtaking speed, however, high resolution is also garnering attention. Thus, Shimadzu is fulfilling LC user demands with two types of systems, the Prominence UFLC, which provides ultra high speed analysis without sacrificing resolution, and the Prominence UFLCXR, which achieves very high resolution while maintaining ultra high speed.

Fig. 1: Prominence UFLCXR

2. The Advantage of Ultra High Speed Analysis - Reducing Limitations

The transition from LC to ultra fast LC reduces some of the limitations normally associated with LC. For example, when the business involves continuous processing of multiple samples, each of which takes a long time to complete, the need to conduct re-analysis for whatever reason can result in product delays, possibly tarnishing the company's reputation. For business requirements like this, ultra high speed analysis means shortening of the time required to complete analysis, thereby reducing the risks associated with time-sensitive analyses. This is a case where “ultra high speed = shorter time” can effectively address the inherent risks.

3. Limitations Not Addressed by Ultra High Speed Alone

As stated above, shortening of analysis time through ultra fast analysis reduces delay risks. However, when analysis is conducted using a typical UV absorbance detector, unforeseen adverse consequences can occur even when using ultra fast analysis. Typical examples of this would be variations in peak retention time due to faulty preparation of the mobile phase, or peak misidentification due to unanticipated elution of impurities. Correct quantitation cannot be obtained if the peak of interest is misidentified. Furthermore, if elution of an unanticipated impurity coincides with that of the target analyte, the inability to distinguish between these could lead to unknowingly reporting a completely incorrect quantitation result. Thus, while chromatography is suitable for analysis of substances that can be separated, there are also inherent risks associated with this analytical method.

4. Reducing Limitations of LC Analysis

Are there any remedies available for reducing the inherent limitations of LC analysis? One approach would be to conduct a thorough investigation when developing the analytical method. In addition to this, it is necessary to ascertain that such limitations are reduced during actual routine analysis.

When LC analysis is conducted using an ordinary detector like an absorbance detector, only retention time information can be considered reliable, and this single-criterion evaluation can lead to greater risk exposure. If useful information other than retention time could be obtained, the inherent limitations of LC analysis would be reduced.

5. Use of MS as an LC Detector

One method of obtaining new and more useful information is to use a mass spectrometer (MS) as an LC detector. The greatest advantage of using an MS as an LC detector is that mass information for each peak can easily be obtained at the same time as the respective retention times. The availability of such mass information provides a powerful means of reducing the possibility of peak misidentification and elution of unanticipated impurities inherent in LC analysis. It also allows for better quantitation in the case of overlapping peaks.

However, setting up an MS as an LC detector normally requires transformation of a typical LC into an ultra high speed LC to enable ultra fast analysis. This is because, in the case of “ultra fast LC + MS”, ultra high speed MS measurement performance is required to detect and quantitate the peaks generated at ultra high speed.

6. Birth of the Single Quadrupole Ultra-Fast LC/MS “LCMS-2020”

As explained above, building an LC/MS system that employs an MS as an LC detector can effectively reduce the limitations of LC analysis. In addition to this, reducing those limitations to the greatest extent possible requires an MS that can handle ultra high speed analysis.

The new “LCMS-2020” single quadrupole ultra-fast LC/MS, boldly addresses these requirements.

The principle features of the LCMS-2020 are described in the following paragraphs.

7. LCMS-2020, Ultra Fast LCMS System

The LCMS-2020 is the first quadrupole LCMS instrument specifically designed to work with ultra fast HPLC. It is capable of providing more data points and faster scans than any previous quadrupole LCMS instrument, allowing it to handle the fastest small-particle and high-efficiency columns.

8. UFLC Quality

Not only does the LCMS-2020 deliver excellent high speed performance, it also delivers data of the highest quality. The Prominence UFLC(XR), which has now become a byword for ultra fast LC, has a well-established reputation for generating high quality data. And it is the phrase “UFLC Quality” that expresses this feature through the speed of the LCMS-2020.

The LCMS-2020 can be combined with the Prominence LC to create an analytical system for routine analysis, or can be combined with the Prominence UFLC(XR) to form an ultra high speed analytical system, demonstrating its strengths for both routine as well as ultra fast analysis.

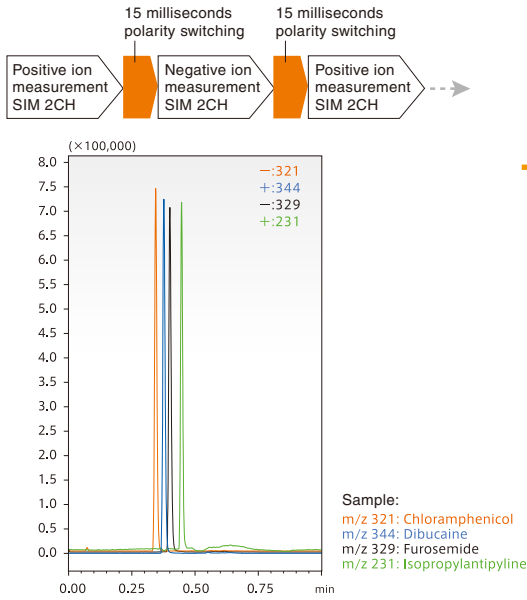

Fig. 2: UFswitching

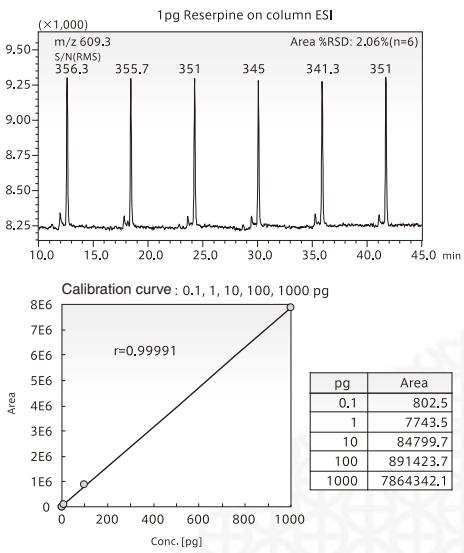

Fig. 3: UFsensitivity

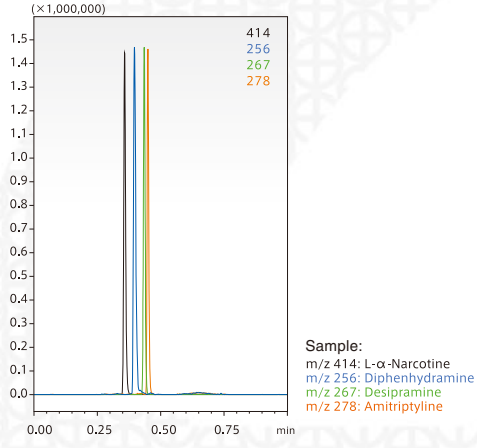

Fig. 4: UFscanning

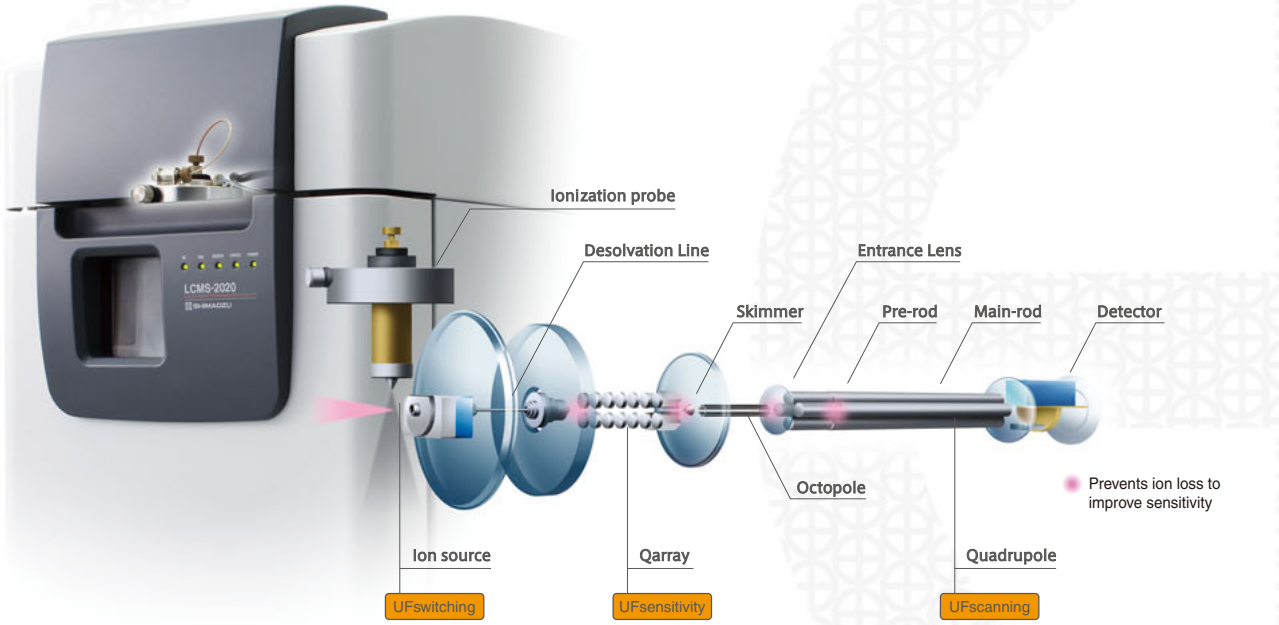

Fig. 5: LCMS-2020 Schematic Diagram

9. Speed is Power

Sharp peaks are generated when conducting ultra high speed HPLC analysis. When an MS is used as an ultra fast LC detector, ultra high speed MS measurement is essential for measuring sharp peaks. With the LCMS-2020, there are 3 aspects of ultra high speed (Ultra Fast):

- UFswitching
- UFsensitivity
- UFscanning

Thus, the overall speed of the LCMS-2020 results from the synergistic effect of the 3 UFs.
Following is a closer look at each of these 3 UFs.

9-1. UFswitching

Ultra Fast 15 msec Polarity Switching

To allow both positive and negative ion detection, measurement is performed while alternately switching between positive and negative ionization modes. The LCMS-2020 incorporates a new high voltage power supply technology (patent pending) that provides the ultra fast polarity switchover time of 15 msec (See Fig. 2).
In the displayed chromatogram, peaks 1 and 3 are negative ion peaks, while peaks 2 and 4 are positive ion peaks. In this way, ultra high speed analysis is conducted with positive and negative ion peaks appearing alternately, one after another, demonstrating the value of this UFswitching function.

9-2. UFsensitivity

Excellent Sensitivity with Ultra Fast Analysis

Excellent sensitivity, repeatability and linearity are achieved with the newly developed ion optical system and new Qarray® optics (See Fig. 3).
The peak area repeatability (%RSD) during repeat injection analysis is excellent. Excellent linearity over a concentration range of 0.1 pg to 1000 pg is seen in this example). High sensitivity (in this example, S/N 350 for 1 pg of reserpine) during ultra fast analysis is achieved without sacrificing data quality.

9-3. UFscanning

15,000 u/sec Ultra High Scan Speed

During scan measurement, the RF voltage applied to the quadrupole is controlled according to the scan speed and m/z. Using a new technology (patent pending) to control ion transmission, Shimadzu achieves a high throughput of larger mass ions (See Fig. 4) while maintaining high resolution, even during ultra high speed scanning. The LCMS-2020 achieves ultra high speed scanning of up to 15,000 u/sec. Because this ultra high speed scanning can be conducted over a wide mass range, highly reliable data can be obtained even during ultra high speed analysis with exceptionally narrow peak widths.

Fig. 6: LCMS-2020

9-4. UFscanning and UFswitching

The power of the LCMS-2020 in ultra fast analysis is demonstrated at its maximum during simultaneous use of UFscanning (ultra fast scanning) and UFswitching (ultra fast polarity switching).
As can be seen in Fig. 7, simultaneous use of UFscanning and UFswitching is possible for ultra fast MS measurement even when multiple compounds must be separated in just seconds.

10. Seeing is Believing

The LCMS-2020 can be considered a new type of LC/MS which has sufficient capability to be used with ultra-fast LC, and reduces limitation of conventional LC.

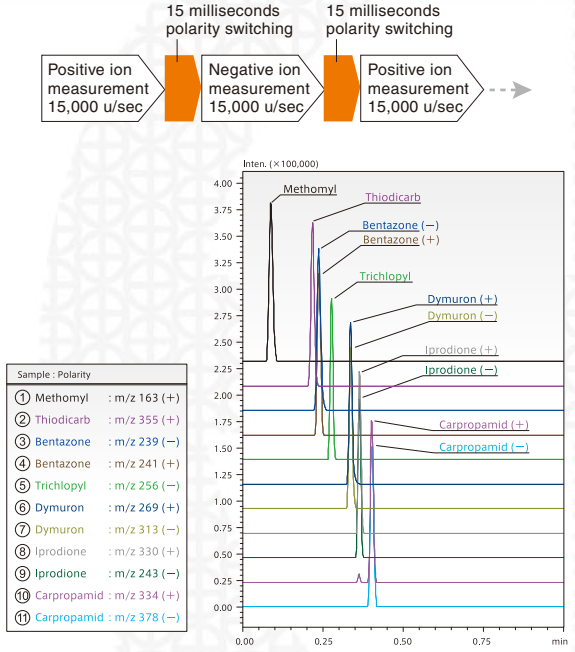

Fig. 7: UFscanning & UFswitching

Fig. 8: LCMS-2020 System

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