

Product Focus: Mass Spectrometry

Solving Complex Challenges Through Powerful Analytics

Introduction courtesy of Glenn Cudiamat, General Manager of Top-Down Analytics

Mass spectrometry (MS), a technique that measures the mass-to-charge ratios of gas-phase ions to identify and quantify the molecules in a sample, is a technology used in a growing number of fields. The estimated market size for MS in 2017 was \$4.2 billion, accounting for 8% of the total market for lab analytical instruments. Through 2018, the MS segment is expected to outperform the analytical instruments market, with 6.9% growth forecast for 2018. Key applications include the OMICS, such as metabolomics/lipidomics and proteomics, in addition to disciplines such as environmental sciences, forensics and pharmacokinetic studies. Although MS has been around for over a century, until relatively recently its application was limited to analytical chemistry labs. Some of the most prominent technologies dominating the mass spectrometry market include triple quadrupole liquid chromatography MS (LC-MS/MS), Quadrupole Time-of-Flight (QTOF), Orbitrap, Fourier-Transform Ion Cyclotron Resonance (FT-ICR), Gas Chromatography MS (GC-MS), Matrix-Assisted Laser Desorption/Ionization (MALDI)-TOF and Single Quad LC-MS.

Maximizing sensitivity

Sensitivity is critical to mass spectrometry analyses and MS offers increased sensitivity over most other analytical techniques. The **Waters® Xevo® TQ-XS tandem quadrupole mass spectrometer** features a unique combination of ionization technologies, ion optics and detection system resulting in levels of sensitivity not previously seen for quantitative ultra performance liquid chromatography (UPLC)/MS studies. The StepWave™ XS ion guide helps to remove neutral species while its segmented quadrupole transfer ion optics transmit a focused beam of ions to the Xtended Dynamic Range (XDR) detector, resulting in a 2x to 10x increase in signal/noise over its StepWave predecessor. Scientists can quantify challenging compounds at trace levels - even if they are labile or show poor transmission efficiency.

The Xevo TQ-XS features the proprietary UniSpray™ ionization source option which ionizes a wider range of analytes from a single chromatographic run while increasing the response across a broad range of compound polarities. It is now possible for analytical scientists to consolidate several analytical methods into one, or eliminate the need to change ionization sources between analyses, saving time and increasing laboratory efficiency.

Waters Xevo TQ-XS



Each Waters Xevo MS features a universal ion source architecture: interchangeable ion sources that can be fitted to, or removed from, the face of the MS in minutes, without the need to shut down the system. This has changed the way analytical scientists working in high-throughput labs, and with little previous MS experience, can maximize the performance and productivity of their instrumentation.

Agilent has recently introduced the **Ultivo Triple Quadrupole LC-MS**, allowing highly sensitive and reliable high-throughput sample analysis from complex biological matrices. The Ultivo's high sensitivity is borne from its greater ion transmission efficiency, making the instrument ideal for food and environmental routine testing. Its small size – 70% smaller than traditional LC/TQ instruments – gives the Ultivo the smallest footprint on the market, and its unique stacking capability frees up additional bench space, answering customers' ongoing requirement for more lab space.

The innovative dodecapole cyclone ion guide compresses the ion beam, leading to higher ion transmission efficiencies and enhanced data quality. The new Vortex Collision Cell increases sample throughput by providing efficient dissociation of ions in the cell, improved focusing and transmission of ions, and rapid clearance of the cell between mass transitions, thereby allowing for more MRMs/sec, zero crosstalk and greater confidence in results by removing background noise.

Minimal downtime and streamlined maintenance are critical for return-on-investment. The Ultivo's VacShield simplifies ion injector maintenance, enabling lab personnel to quickly and seamlessly maintain the instrument and increase throughput. Also maximizing instrument operation are enhanced Intelligent Diagnostics tools, enabling the Ultivo to monitor several parameters in real time to rapidly troubleshoot any issues.



Agilent Ultivo TQ-LC/MS

Speed with certainty

The **Thermo Scientific Q Exactive HF-X hybrid quadrupole-Orbitrap Mass Spectrometer** sets new standards for extremely fast and accurate analyses of highly complex protein samples, enabling scientists to advance disease research and drug discovery. Applications span the translational research and biopharma spectrum, including comprehensive proteome profiling and quantitation, biomarker discovery and verification, and full characterization of complex biotherapeutics.

The Q Exactive HF-X MS delivers the same number of protein identifications in half the time required by similar models, significantly increasing throughput and productivity. One user has managed to identify 1,100 unique peptides per minute, setting a new world record. Superior ion transmission arises from cutting-edge design features, such as the high capacity transfer tubes (HCTT) and electrodynamic ion funnel. This novel architecture, together with new scan rates of up to 40 Hz, multiplexing up to 10 precursors per second and on the fly polarity switching to reduce run time for both positive mode and negative mode analysis in parallel, drives

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Thermo Q Exactive HF-X MS



more efficient use of the Orbitrap mass analyzer and boosts sensitivity for all analytes.

Designed to facilitate superior high-resolution accurate-mass (HRAM) performance with 240k (FWHM) at m/z 200 and sub ppm mass accuracy, the Q Exactive HF-X MS provides scientists with confidence in their results: the system has been developed to advance even the most challenging and rigorous research and development workflows, delivering two-to-three-fold sensitivity improvements. Biopharma laboratories can benefit from up to eight times better signal-to-noise ratio for native, intact monoclonal antibody mass determination, glycoprofiling and purity checks.

Maintain quality standards

It is critical for MS instrumentation to maintain data quality while maximising speed and sensitivity. **Bruker Daltonics** has recently introduced the **timsTOF Pro** for quantitative shotgun proteomics research. Its dual trapped ion mobility spectrometry (TIMS)-powered **Parallel Accumulation Serial Fragmentation (PASEF)** technology enables sequencing speeds of >100 Hz without compromising sensitivity or resolution. With PASEF, parallel accumulation of ions occur in the first TIMS section while the TIMS-separated ions are released from a second TIMS analyzer section, resulting in a duty cycle near 100%. Bruker's timsTOF Pro is the only instrument on the market with PASEF technology, providing a significant advantage over the limitations of gated, tandem-in-time, FT-based MS analyzers.

The TIMS separation in the PASEF method focuses ions in time and space according to their mobility, resulting in high density ion packets consecutively eluting within a total TIMS scan time of just 100 ms. For PASEF MS/MS scans, the mass selection window is synchronized with the elution times of the specific ion packets from the TIMS analyzer, allowing it to fragment > 10 selected precursors during the 100 ms TIMS scan. This combination of technologies allows faster acquisition of data-dependent MS/MS spectra, with improved sensitivity and no compromise in spectral quality.

In contrast to most current MS instruments where large sample amounts (> 1 μ g) are needed, the speed and sensitivity of dual TIMS-powered PASEF allows low peptide loads (< 200 ng), yielding identification of thousands of proteins with quantitation over nearly four orders of magnitude of dynamic range.

Optimize productivity

Designed to bring real-time mass detection to laboratories and processing facilities, **Microsaic's** chip-based, miniaturized MS technology allows agile sample detection and identification at the point of use. Providing access to more detailed sample data at the point of need, the compact, easy to use MS systems enable operators to make faster, real-time decisions, optimizing overall productivity. The newly released **4500 MiD[®]** combines the vacuum system, electronics and computer inside one box. With no floor pump ever needed, it can be installed where no other MS can be easily deployed, all while retaining the performance of a conventional MS system. The addition of the Microsaic MiDas[™] compact interface sampling module means the 4500 MiD[®] can be easily deployed in a large variety of on-line, at-line and off-line applications.

Featuring Microsaic's three main patented chip-based technologies, the ionchip[®], spraychip[®] and vac-chip[™], the 4500 MiD[®] is reliable and user-friendly, with increased mass range, a completely tool-less front-end for enhanced control and an intuitive and robust user interface. A change in front-end alignment has also strengthened system uptime while reducing the deposition of contaminants downstream. Increasing the mass range to 1400 m/z , opens up a new range of applications, including peptide analysis. This application is ideal for the 4500 MiD[®]'s efficient ESI source, and its strong propensity towards multiple charging.

Easy to operate and maintain, the Microsaic 4500 MiD[®] also offers reduced solvent, nitrogen and power consumption, reducing operating costs and providing a greener solution for mass detection.

JEOL MALDI Imaging SpiralTOF



Mass Spectrometry Imaging

The combination of time-of-flight (TOF) MS and MALDI direct ionization sources has gained popularity in recent years, and is commonly used in proteomics, polymer analysis and mass spectrometry imaging. The **MALDI SpiralTOF[™]** from **JEOL** introduces MALDI imaging with the highest performance MALDI TOF/TOF system, to assess the distribution of proteins, peptides, lipids, drugs, and metabolites in tissue specimens, as well as the compound distribution in organic materials. The MALDI SpiralTOF[™] features "Perfect Focusing" ion optics, reducing loss in ion transmission due to beam divergence.

Traditionally, differences in sample thickness affect the flight time in conventional TOF mass spectrometers, leading to a loss in mass resolving power and mass accuracy for non-flat samples. However, the MALDI SpiralTOF[™]'s 17-metre flight path minimises the errors that arise from inevitable variations in sample thickness, which is critical for obtaining the accurate spatial distribution of a specific compound without noise from background interferences.

High mass-resolving power is important when observing how two different compounds with slightly different masses are distributed in tissue – for example in the brain. The MALDI SpiralTOF[™] can separate two peaks that differ by only 0.09 u. Other key features include linear TOF for high-mass analysis, and optional TOF/TOF with high-resolution single-isotope precursor selection for MS/MS imaging with high-energy collision-induced dissociation (CID).

Companies mentioned in this Product Focus

Agilent Technologies	www.agilent.com
Bruker Daltonics	www.bruker.com
JEOL	www.jeolusa.com
Microsaic	www.microsaic.com
Thermo Scientific	www.thermoscientific.com
Top-Down Analytics	www.tdaresearch.com
Waters Corporation	www.waters.com

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