About Magnetic Sector Mass Spectrometers

Double-focusing magnetic sector mass spectrometers provide high sensitivity, high resolution, and a reproducibility that is unmatched in any other kind of mass analyzer.

A double-focusing magnetic sector mass spectrometer has at least four components:

- An *ion source* in which ions are formed and accelerated to energies of up to as high as 10 kilovolts.
- A *magnetic sector* with a magnetic field that exerts a force perpendicular to the ion motion to deflect ions according to their momentum.
- An *electric sector* with an electric field that exerts a force perpendicular to the ion motion to deflect ions according to their kinetic energy.
- A *detector* that produces a response that is proportional to the number of ions.

Slits are placed in the ion path to define the positions and energies of the ions that strike the detector. In general, decreasing the slit widths increases the mass resolution but reduces the number of ions that are detected. Additional electrostatic lenses are commonly used to shape and deflect the ion beam to optimize peak shape and maximize ion beam transmission from the source to the detector. JEOL uses octapole and quadrupole focusing lenses to simplify the ion optical design.

Collision chambers in the *first field-free region* (just after the ion source) and *second field-free region* (just after the magnet and before the electric sector) are used to induce ions to fragment in collision-induced-dissociation experiments (MS/MS).

The term "double-focusing" refers to the fact that the combination of electric and magnetic sectors focuses ions according to both direction and energy to provide higher resolution than can be obtained with a single magnetic sector.

A *forward-geometry* mass spectrometer such as the has ion optics in which the electric sector is placed before the magnetic sector.

A *reverse-geometry* mass spectrometer such as the GCmate, SX102, and MStation has ion optics in which the magnetic sector is placed before the electric sector.

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Features of JEOL magnetic sector mass spectrometers:

JEOL's modern magnetic sector mass spectrometers are faster, more sensitive and much easier to operate than their predecessors.

Speed: The maximum scan speed is determined by magnet response and depends on magnet construction and magnet size. Magnetic sector mass spectrometers can be scanned at relatively fast rates. *The JEOL GCmate magnet can be scanned at a rate of 70 milliseconds per scan*.

Sensitivity: Sensitivity is influenced by several factors including ionization efficiency, transmission efficiency, and detector response. The relatively high accelerating voltage in a magnetic sector mass spectrometer improves ion transmission and detector response. Although sensitivity is inversely related to resolution, *a magnetic sector mass spectrometer can have a sensitivity in electron impact mode that is at least an order of magnitude better than can be obtained with a quadrupole mass spectrometer.*

An array detector is an option that provides simultaneous detection over a portion of the mass range. *This can improve a JEOL mass spectrometer's detection sensitivity by about a factor of 50 over that obtained by using a conventional point detector.*

Ease of operation: *All JEOL mass spectrometers make use of very simple ion optics that provide high performance and ease-of-use*. Computer control can make it very easy to set up the mass spectrometer and optimize or diagnose the performance for a particular analysis. Modern magnetic sector mass spectrometers like the JEOL GCmate and MStation are fully automated. All JEOL mass spectrometers have virtually foolproof "fail-safe" vacuum control systems and high voltage interlocks.

Reproducibility: JEOL mass spectrometers use a Hall-effect probe to monitor the magnetic field and ensure scan-to-scan reproducibility. This means that *a low-resolution calibration can be stable for periods of several months to a year.*

Compared to "active" mass analyzers such as ion traps, ion cyclotron resonance and quadrupole mass analyzers, the motions and energies of ions in a magnetic sector mass spectrometer are relatively simple to describe and are extremely well-characterized. Relatively short ion source residence times and ion flight times in a magnetic sector mass spectrometer severely limit the interactions of ions with neutral molecules and other ions. This minimizes space-charge effects (ion-ion repulsion) and ion-molecule reactions that would adversely affect the reproducibility of mass spectra. *Magnetic sector mass spectrometers are the method of choice for quantitative analysis by mass spectrometry.*

Resolution: *All JEOL magnetic sector mass spectrometers can provide high resolution mass spectra*. High resolution is important to separate and identify closely spaced masses. Accurate mass measurements to determine elemental compositions are virtually always performed in high-resolution mode to avoid overlapping masses and to improve the accuracy of peak assignment. Accurate mass measurements are an invaluable tool in interpreting mass spectra and confirming elemental compositions.

MS/MS: *The magnetic and electric sectors in any JEOL magnetic sector mass spectrometer can be scanned together in "linked scans" that provide powerful MS/MS capabilities without requiring additional mass analyzers*. Linked scans can be used to obtain product-ion mass spectra, precursor-ion mass spectra, and constant neutral-loss mass spectra. These can provide structural information and selectivity even in the presence of chemical interferences. JEOL mass spectrometers can perform fast linked scans for GC/MS/MS and LC/MS/MS experiments.

Relatively high (kilovolt) collision energies in magnetic sector mass spectrometers provide greater information content and higher reproducibility than collision-induced dissociation experiments performed at lower collision energies in other kinds of mass analyzers. Improved selectivity can be obtained by combining a double focusing mass spectrometer with additional mass analyzers to make a tandem or hybrid mass spectrometer.