The History of Magnetic Sector Mass Spectrometry at VG - Micromass - Waters

Mike Morris, Bob Bateman, Tim Riley, Lance Nicolaysen, Viki Brooks

EARLY DAYS

The commercial history of mass spectrometry in Manchester, England dates back to the 1940s with the development of a mass spectrometer by Metropolitan Vickers for the separation of Uranium isotopes (MT1) for James Chadwick at the University of Liverpool. Metropolitan Vickers became AEI (Associated Electrical Industries).

Vacuum Generators was a company based in the south of England manufacturing components for vacuum systems. Robert Craig, an engineer, started a business at AEI. His vacuum generator was sold in 1963.

In 1970, the first device manufactured by VG Micromass was the MM1 1cm radius 180° magnetic sector instrument for residual gas analysis. This was followed by the first single focusing instrument MM70 in 1970 and the MM71 in 1971 in parallel with this, quadrupole mass filters were also produced, with the Q1 (mass range 120) and the Q6 (mass range 550).

One of the major breakthroughs in magnetic technology was the introduction of a Knudsen cell. This was delivered to the Department of Pharmacology at Oxford University in 1975, and presented to the Museum of Science and Industry in Manchester, England when it was decommisioned in 1996.

The timeline for the evolution of the company is shown in the table below, culminating with the full integration of the VG/Micromass businesses with Waters in 2012.

70-70

In 1974, VG Micromass was formed in 1974. The first double focusing mass spectrometer constructed by VG was the 7.5° radius, 70° magnetic sector, and known as the MM 70-70. The instrument was made for Sheffield University, and was constructed in a vertical geometry - the only VG double-focusing instrument to be built in this orientation.

The historical geometry of the ZAB instrument was configured with a detector after the magnet as well as after the electric sector, and allowed it to be operated as both a single- and double-focusing instrument. This configuration also allowed for mass selection after the magnet to allow for MS/MS experiments.

The same principle of rotating the magnet pole faces to extend the mass range was also applied to the ZAB series of instruments, with the ZAB-SE including a 20° radius high-field magnetic sector defining a ring of 13,000 at 8V accelerating potential.

The radial geometry of the ZAB instrument was configured with a detector after the magnet as well as after the electric sector, and allowed it to be operated as both a single- and double-focusing instrument. This configuration also allowed for mass selection after the magnet to allow for MS/MS experiments.

HIGH MASS

The advent of commercial fast-atmospheric bombardment (FAB) in the early 1980s was a stimulus in the development of high-mass sector instruments. As it allowed the study of biomolecules directly, which were previously inaccessible by mass spectrometry. The mass range of a magnetic sector is essentially eliminated eddy currents which permitted fast transmission and stability at a reduced mass range. However, as the radius of the magnet is increased, the whole instrument must be scaled up in order to maintain the double focusing properties of the three sectors to fulfill the double focusing requirements of the ion beam at the detector, while still having the advantages of both the 70 series (forward geometry, BE) and ZAB series (reverse geometry, BE) instruments.

1980s saw the introduction of the In-sector-Autospec at the IMSC Conference in Bordeaux France. This sector instrument, of geometry IBE, used the energy and angular dispersion of the first focusing stage into the electric sector, and had zero first and second order alpha (angular divergence) and beta (energy divergence) aberrations.

A special version of the Autospec was made in 1989 for CDC in New South Wales, Sydney, published a paper on an MS/MS tandem mass spectrometer with a collision cell positioned after the magnetic sector. This instrument was known as the Autospec tandem, and effectively quadrupled the mass range of the mass spectrometer.

The last sector instrument from the VG-Micromass-Waters stable - Autospec - was housed from the Infantcare facility in the UK in December 2016.

In 1995, an array detector was introduced as the first detector in a multi-sector tandem - the ZAB-T with a novel focal-plane geometry as the second analyser. These devices were particularly suited to the collection of product ion mass spectra with minimal chemical noise. The instruments themselves, however, were substantial pieces of hardware.

EARLY DAYS

1960s

VG Instruments Group formed (Vacuum Generators Ltd)

1970s

VG Micromass formed in speciality MS

VG Organic instruments formed (Organic MS)

VG Analytical Parent

VG products distributed in the US by the Knudsen Group

VG Instruments Group purchased by Philips Instrument Co

VG Biomedical Parent

Evolution of VG’s product lines from inverse to forward TOF
diagram (1960s-1980s)

1990s

VG Analytical MS

VG MicroMass Tandem MS

VG Micromass Manchester head office

VG Micromass MS1

VG Micromass Autospec OA

VG Micromass Autospec ToF

REFERENCE: