CSIR NET Life Science Unit 13

Different Types of Mass Spectrometry

Mass spectroscopy is an analytical technique in which ionization and mass analysis of compounds are employed to analyse and determine the formula, mass, and structure. A component of the mass spectrometer known as a mass analyser takes ionized masses and separates them based on charge to mass ratios and outputs come to detector where they are detected and later converted to a digital output.

There are the following types of mass analysers are generally founds that can be used for ion separation in mass spectroscopy.

1. MALDI-TOF Mass Spectrometry
2. Quadrupole Mass Analyzer
3. Time of Flight Mass Analyzer
4. Magnetic Sector Mass Analyzer
5. Electrostatic Sector Mass Analyzer
6. Quadrupole Ion Trap Mass Analyzers
7. Ion Cyclotron Resonance

1. Matrix-assisted laser desorption ionization-time of flight mass spectrometry (MALDI-TOF MS) -

This is a commonly used Mass Spectroscopy technique. it is an ionization technique that softly creates ions with minimal fragmentation for this laser energy is used. In MALDI-TOF, the ion is protonated and protonated ions are accelerated by an electric field to by this ion have the same kinetic energy as any other ions that have the same charge. This velocity depends on the mass-to-charge (m/z) ratio and the time takes for the ion to reach a detector is measured. MALDI-TOF analyses a wide variety of biomolecules, including peptides carbohydrates, and other macromolecules.

2. Quadrupole Mass Analyzer -

In this type of Mass analyser, all the charged molecules is accelerated by DC bias and move away from the centreline, the proportional rate being to their charge to mass ratio. If their course goes off too far, they will hit the metal rods or the

sides of the container and be absorbed. After that the DC bias acts like the magnetic field B of the mass spectra and it can be tuned to specific charge to mass ratios and hitting to the detector.

In this type of electric field cause by, sinusoidal electric fields at 90 orientation and 90 degrees phase shift this condition oscillates as a circle over time. So as an aftereffect the charged particles fly down toward the detector, and particles will be traveling in a spiral, the diameter of the spiral being determined by the charge to mass ratio of the molecule and the frequency and strength of the electric field.

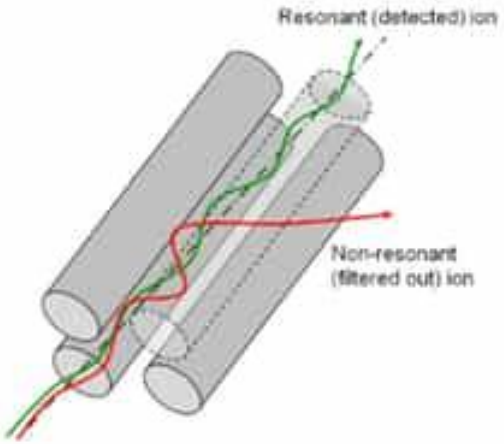

Fig. A quadrupole Mass analyser

3. Time of Flight (TOF) Mass Analyser-

In this type of analyser, ions is separated by time without using an electric field or magnetic. Means TOF is like tas chromatography, but there is no any phase like stationary/ mobile phase used, and separation of ions is based on the kinetic energy and velocity.

In this process Ions having same charges have the equal kinetic energies; so that kinetic energy of the ion in the flight tube is equal to the kinetic energy of the ion as it leaves the ion source:

$$KE = \frac{mv^2}{2} = zV$$

(1)

And flight time, or time it takes for the ion to travel the length of the flight tube is:

$$T_f = \frac{L}{v}$$

(2)

Where L denotes is the length of tube and

v denotes the velocity of the ion

when Equation 1 Substituting for kinetic energy in Equation 2 for time of flight:

$$T_f = L\sqrt{\frac{m}{z}}\sqrt{\frac{1}{2V}} \propto \sqrt{\frac{m}{z}}$$

At the time of analysis, length of tube L, ion source Voltage V are held constantso the time of flight is directly proportional to the root of the mass to charge ratio.

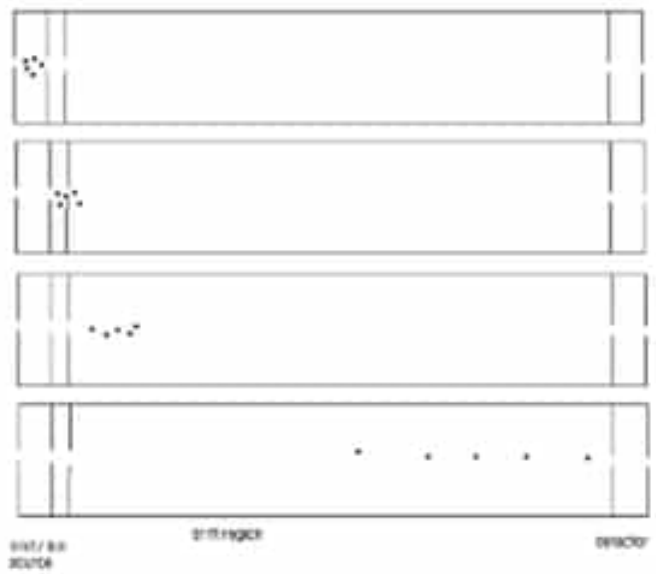

Fig. A TOF System

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4. Magnetic Sector Mass Analyzer-

Like TOF analyser, in magnetic sector analysers process acceleration of ions occurs through a flight tube, and ion separation of occurs by charge to mass ratio. For separating the ions magnetic sector and TOF magnetic field differences is used. Deflection incharges occurs when moving charges enter a magnetic field, this deflection occurs to a circular motion of a unique radius in a direction perpendicular to the applied magnetic field. in the magnetic field Ions experience equal two forces; one force is due to the magnetic field and the other is from centripetal force.

$$F_B = zvB = F_c = \frac{mv^2}{r} \tag{4}$$

Where the equation can be rearrange

$$v = \frac{Bzr}{m} \tag{5}$$

After substituting the equation to kinetic energy

$$KE = zV = \frac{mv^2}{2}$$

$$\frac{m}{z} = \frac{B^2r^2}{2V}$$

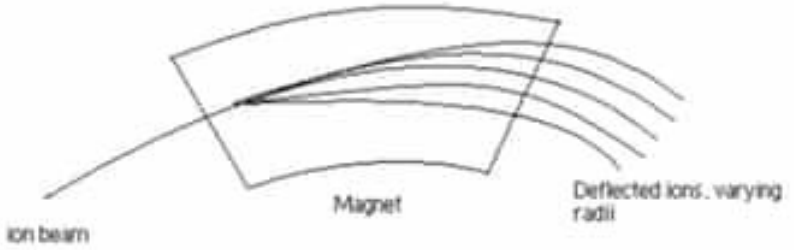

Fig. Magnetic Sector separator

Because of certain ions m/z value will have a unique path radius which this value can be determined only if magnetic field magnitude B , and voltage difference V both acceleration are held constant. When passing of similar ions happens through the magnetic field, deflection of all ions will be happens to the same degree and all will follow the same trajectory path. And the ions which are not selected by V and B values, they will collide with either side of the flight tube wall or will not pass through the slit to the detector. This particular spectroscopy are used for mass focusing, they focus angular dispersions.

5. Electrostatic Sector Mass analyser-

This technique is similar to time of flight analyser types in this separation of ion occurs by using electric field. This analyser have two curve plates with equal and opposite potential. When ions will travel through electric field it will deflected and force on ion feel due to electric field which is equal to centripetal force on ion. So by the reaction ions having same kinetic energy are focused and ion having different kinetic energy are get dispersed.

$$KE = zV = \frac{mv^2}{2}$$

$$F_E = zE = F_c = \frac{mv^2}{R}$$

The main function of Electrostatic sector analyzers is energy focusers, in which the ion beam is focused for energy. This technique is employed when the instrument is individually and single focusing. If both techniques are used together, then it is called a double-focusing instrument., because, at that time in the instrument, both the energies and the angular dispersions are focused.

6. Quadrupole Ion trap Mass Analyser -

This analyser has the same principles as a quadrupole analyser, for separation of the ions by mass to charge ratios this analyser uses an electric field. it is made up of a ring electrode of a particular voltage and cap electrodes are grounded to the end.entry of ions occurs between the area of electrodes through one of the end caps. Usually, a quadrupole ion trap runs a mass selective ejection, where selectively it ejects the trapped ions in order of increasing mass by a gradual increment of the applied radiofrequency voltage.

7. Ion Cyclotron Resonance (ICR) -

In Ion Cyclotron Resonance (ICR) technology an ion trap uses a magnetic field for trapping ions into an orbit or inside it. In this type of analyser, no separation occurs all the ions of a specific range are trapped inside, and an external electric field generates a signal. when a moving charge enters a magnetic field, a centripetal force experiences which makes the ion in orbit.