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M.Sc. Chemistry

Semester IV (CBCS)

C 401 Advanced spectroscopic techniques

Mass spectrometry

(Introduction, instrumentation, application)

Prepared by,

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Mass Spectrometry

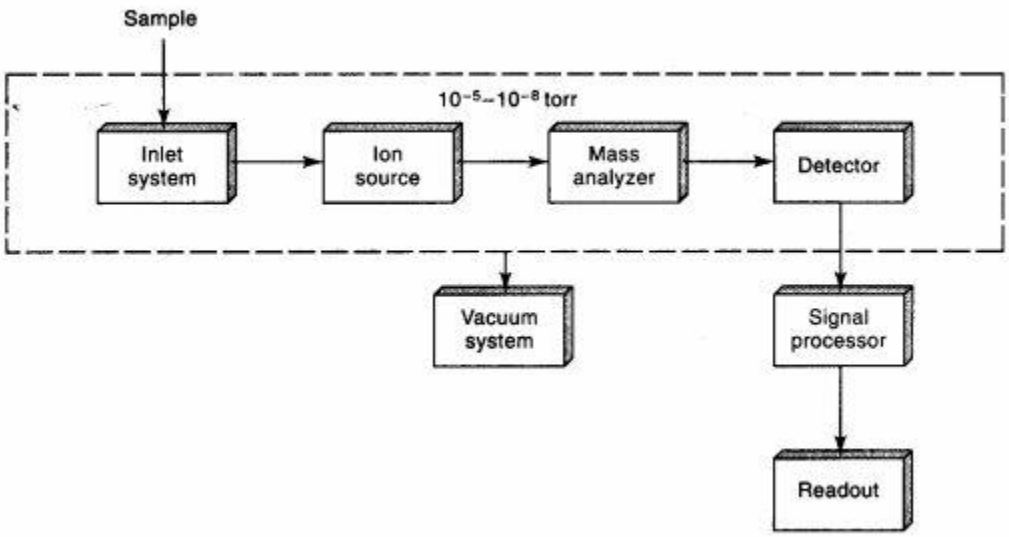
- Mass spectrometry is a powerful analytical technique used to quantify known materials, to identify unknown compounds and to elucidate the structure and chemical properties of different molecules.
- In mass spectrometry, the molecular weight of compounds can be analyzed under specific condition.

Steps involve in mass spectrometry analysis

There are following steps involved in mass analysis.

- Sample convert into gaseous form (for liquid and solid sample)
- Ionization
- Acceleration
- Separation according to m/z ratio (mass analyzer)
- Detector

Draw the block diagram of mass spectrometer



Components

The instrument consists of three major components:

1. **Ion Source:** For producing gaseous ions from the substance being studied.
2. **Analyzer:** For resolving the ions into their characteristics mass components according to their mass-to-charge ratio.
3. **Detector System:** For detecting the ions and recording the relative abundance of each of the resolved ionic species.

With all the above components, a mass spectrometer should always perform the following processes:

1. Produce ions from the sample in the ionization source.
2. Separate these ions according to their mass-to-charge ratio in the mass analyzer.
3. Eventually, fragment the selected ions and analyze the fragments in a second analyzer.
4. Detect the ions emerging from the last analyzer and measure their abundance with the detector that converts the ions into electrical signals.
5. Process the signals from the detector that are transmitted to the computer and control the instrument using feedback.

- Because ions are very reactive and short-lived, their formation and manipulation must be conducted in a vacuum. Atmospheric pressure is around 760 torr (mm of mercury).
- The pressure under which ions may be handled is roughly 10^{-5} to 10^{-8} torr.

One mark question answer

Sr No.	Question	Answer
1	Pressure required in mass analyzer in mass spectrometry	10^{-5} to 10^{-8} torr
2	In Mass spectrometry, in ion source chamber _____produced	Radical ion
3	In mass spectrometry, work of mass analyzer is _____	mass-to-charge ratio

Types of ionization techniques based on energy supply

According to energy supply in ionization source, the techniques divided into two parts

(1) Soft ionization techniques

(2) Hard ionization techniques

Soft ionization techniques: In this method, lower energy is given to the compounds for their ionization.

Lower Energy

Less Fragmentation

Clear spectrum

e.g APCI, APPT, ESI

Hard ionization techniques: In this method, highest energy is given to the compounds for their ionization.

Higher Energy

More Fragmentation

Complicated spectrum

e.g EI

Classification techniques according to their application

According to mechanisms of ionization of sample, the ionization techniques divided as follow;

1. Gaseous phase
2. Desorption
3. Evaporation

1. Gaseous phase
    - In this method, first of all compound convert into gaseous phase and then ionized into ion by appropriate method.

      e.g. EI, CI,

2. Desorption
    - In this method, the sample vaporized and ionized parallel.
    - Compound direct convert into gaseous phase and ionized.

      e.g. FD, FAB, MALDI

3. Evaporation
    - In this technique, sample vaporization and ionization was carried out by means of energy transfer.

      e.g. thermospray, electron spray, APCI, APPI

Sample inlet system in mass spectrometer

In mass different sample system used according to types of sample, batch inlets, direct probe inlets, and chromatographic and capillary electrophoretic inlet systems.

Batch Inlets

- The batch inlet system is considered the most common and simplest inlet system.
- This system externally volatizes the sample which leaks into an empty ionization region.
- Boiling points up to 500 ºC of gaseous and liquid samples can be used on typical systems.
- The system's vacuum contains a sample pressure of 10^{-4} to 10^{-5} Torr.
- Liquids are introduced using a **microliter syringe** into a reservoir; gases are enclosed in a area that is confined between two valves before being expanded into a reservoir container.
- Liquids that have boiling points lower than 500 degrees C cannot be used in the system because the reservoir and tubing need to be kept at high temperatures by ovens and heating tapes.
- This is to ensure that the liquid samples are transformed to the gaseous phase and then leaked through a metal or glass diaphragm containing pinholes to the ionization area.

Direct Probe Inlets

- A direct probe inlet is for small quantities of sample, solids, and nonvolatile liquids.

- Solids and nonvolatile liquids are injected through a probe, or sample holder.
- The probe is inserted through a vacuum lock which is designed to limit the volume of air needed to pump from the system after the probe has been inserted into the ionization section.
- The probe is placed extremely close to the ionization source, where the slit leads to the spectrometer, and the sample is held in place on the surface of a glass or aluminum capillary tube or a small cup.
- This position makes it possible for thermally unstable compounds to be analyzed before decomposition because of the low pressure in the ionization area which is in close proximity to the sample. Do to the probe, nonvolatile samples such as carbohydrates, steroids, and metal-organic species can be studied because the low pressures lead to increased concentrations of the nonvolatile samples.
- The principle sample requirement is attainment of an analyte partial pressure of at least 10^{-8} torr.

Chromatographic and Capillary Electrophoretic Inlets

- Chromatographic systems and Capillary Electrophoretic units are often coupled with mass spectrometers in order to allow separation and identification of the components in the sample.
- Electro kinetic and pressure injection controls the amount of volume injected by the duration of the injection, which typically range between 5 to 50 nL (nanoliter).

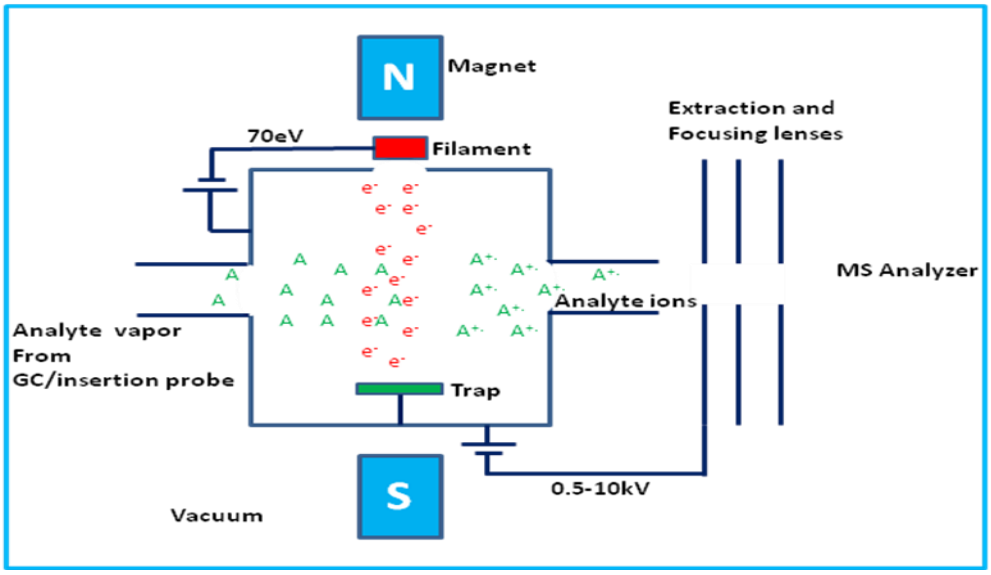
One mark question answer

Sr No.	Question	Answer
1	For liquid sample _____syringe is used for inlet sample	microliter syringe
2	Full form of APCI	Atmospheric Pressure Chemical Ionization
3	Full form of MALDI	Matrix assisted laser desorption ionization
4	For Gaseous phase ionization which techniques are used in mass spectrometry	Chemical ionization, electron ionization

Ionization techniques

Electron ionization (EI)

- Electron ionization (EI, formerly known as electron impact ionization and electron bombardment ionization) is the basis for one of the most efficient mass spectrometry methods for identifying a given organic compound.
- It is an ionization method in which high energy electrons interact with atoms or molecules in gas phases to produce ions.
- In this technique, as source of electron tungsten or rhenium filament is used.
- Filament produce high energy electron which travel across the ionization chamber.
- During this travelling, electron strick over neutral molecule to produced positive radical ion.
- This technique is considered to be a hard ionization method (high fragmentation) because it uses high-energy electrons to generate ions.
- This leads to extensive fragmentation, which contributes to the structural determination of unknown compounds.
- EI is useful for organic compounds with molecular weights below 600.
- In addition, several other thermally stable and volatile compounds in solid, liquid and gas states can be detected with the use of this technique when combined with various separation methods.



- EI is also the method that is most commonly used for GC-MS.
- Neutral molecules are removed from the chamber by vacuum.
- Only positive ions are accelerating by magnet and electrical field.

Advantages of EI

- EI is non-selective ionization and can be ionized as long as the sample can be vaporized.
- EI has high ionization efficiency and sensitivity.
- EI spectrum provides a wealth of structural information and is the "fingerprint" of the compound.
- Use in routine mass analysis
- It is inexpensive
- Excess energy give more ion fragmentation
- From the fragmentation, the structure of unknown compound may be predict

Disadvantages of EI

- The EI source is not suitable for volatile, thermally unstable samples.
- Some compounds are fragile in EI mode and do not give an accurate mass spectra.
- The EI method can only detect positive ions and does not detect negative ions.
- Short lived fragment ion cannot be measure

One mark question answer

Sr No.	Question	Answer
1	Full form of EI in mass spectrometry	Electron ionization
2	In mass spectrometry, EI is _____type ionization technique	Hard ionization technique
3	In EI which metal filament is used for electron spray	tungsten or rhenium filament
4	In EI technique of ion source may increase more fragment ion due to _____type ionization technique	Hard ionization technique

Chemical ionization (CI)

- Chemical ionization (CI) technique is especially useful when no molecular ion is observed in EI mass spectrum of a compound.
- It is one type of soft ionization technique and hence given less fragmentation.
- It is also used in the case of confirming the molecular weight of a compound.
- CI technique uses nearly the same ion source device as in EI, except, CI uses tight ion source, and a reagent gas.
- Generally hydrogen (H2), methane (CH4), isobutane (iso-C4H10) and ammonia (NH3) are used as reagent gases in CI mass spectrometry; with all these CI gases the compounds form protonated molecule ion in their CI spectra.
- Reagent gas is first subjected to electron impact to yield reagent gas ions.
- These initial reagent gas ions further undergo ion-molecule reactions with neutral reagent molecules (R) to yield reagent selective ions (reagent plasma, e.g., RH+).
- When sample is introduced, the sample molecules (A) undergo ion-molecule reactions with reagent plasma to produce sample ions.
- In general, reagent gas molecules are present in the ratio of about 100:1 with respect to sample molecules.
- In this technique Pseudo-molecular ions, $[A+H]^+$ (positive ion mode) or $[A-H]^-$ (negative ion mode) are often observed.

Positive ion mode: $RH^+ + A \text{ ------> } AH^+ + G$

Negative ion mode: [R-H]- + A ------> [A-H]- + G

Primary ion formation

$$CH_4 + e^- \longrightarrow CH_4^{+\bullet} + 2\,e^-$$

Secondary reagent ions

$$CH_4 + CH_4^{+\bullet} \longrightarrow CH_5^+ + CH_3^\bullet$$

$$CH_4 + CH_3^+ \longrightarrow C_2H_5^+ + H_2$$

Product ion formation

$$M + CH_5^+ \longrightarrow CH_4 + [M + H]^+ \quad \text{(protonation)}$$

$$AH + CH_3^+ \longrightarrow CH_4 + A^+ \quad (H^- \text{ abstraction})$$

$$M + C_2H_5^+ \longrightarrow [M + C_2H_5]^+ \quad \text{(adduct formation)}$$

$$A + CH_4^+ \longrightarrow CH_4 + A^+ \quad \text{(charge exchange)}$$

If ammonia is the reagent gas,

$$NH_3 + e^- \longrightarrow NH_3^{+\bullet} + 2\,e^-$$

$$NH_3 + NH_3^{+\bullet} \longrightarrow NH_4^+ + NH_2$$

$$M + NH_4^+ \longrightarrow MH^+ + NH_3$$

For isobutane as the reagent gas,

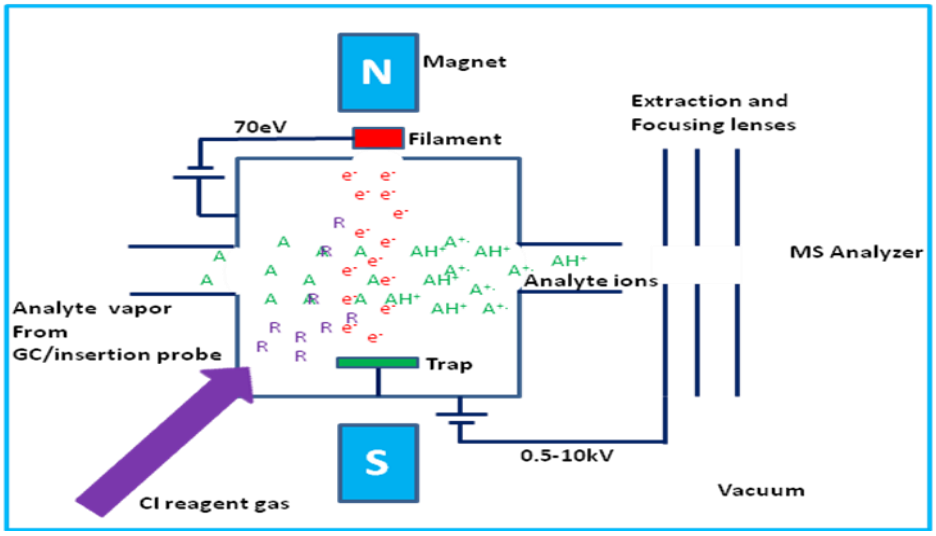
$$C_4H_{10} + e^- \longrightarrow C_4H_{10}^{+\bullet} + 2\,e^- \,(+C_3H_7^+ \text{ and other ions})$$

$$C_3H_7^+ + C_4H_{10}^{+\bullet} \longrightarrow C_4H_9^+ + C_3H_8$$

$$M + C_4H_9^+ \longrightarrow MH^+ + C_4H_8$$

- The fragmentation pattern of protonated molecules obtained under CI conditions may be different from that of the molecular ions observed under EI conditions.

- In CI mass spectrometry the molecules of a vaporized sample are ionized by a set of reagent ions (reagent plasma) in a series of ion-molecule reactions.
- The energy transferred by these reactions is lower than the energy imparted by electrons in EI source, and therefore fragmentation of the sample molecules is greatly decreased.
- For this reason CI mass spectrometry has been finding increasing use as a tool for the molecular weight confirmation and for elucidation of structure of variety of organic compounds including differentiation of isomeric compounds.



Advantages of CI

- It is soft ionization technique which give milder ionization as compare to electron ionization EI
- Lower fragmentation observed
- Possibility of molecular ion peak same as compound molecular weight increases
- Give Pseudo-molecular ions, $[A+H]^+$ peak in mass spectrum

Disadvantages of CI

- Molecule must have lewis acid or lewis base functional group in order to react with reagent plasma
- Sample must thermally volatile and stable
- More equipment require as compare to EI so somehow costly

Fast atom bombardment (FAB)

- Fast atom bombardment is one of the common ionization technique used in organic spectroscopy.
- It is one of the soft ionization techniques in which comparatively supply lower energy to the molecule.
- It is used in determination of molecular weight of biomolecues such as peptide, protein, lipid etc.
- This technique successfully determines compounds that are not volatile or derivatized, as well as some polymer compounds.
- Moreover, it is effective for the determination of oligosaccharides, oligopeptides, oligonucleotides, and thermally labile organic compounds and even metal organic compounds.

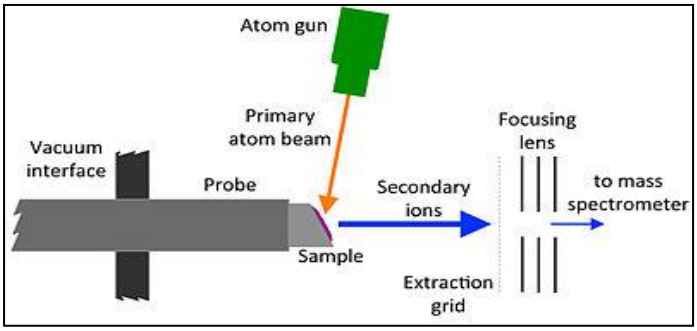
The Principle of FAB

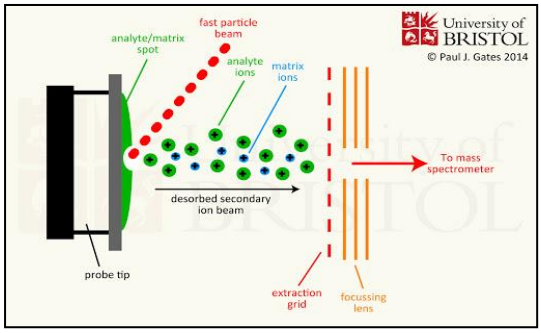
The FAB directly bombards the surface layer of the sample with a high-speed directional movement of neutral atoms, ionizing the sample to form positive ions $[M+H]^+$, negative ions $[M+H]^-$, and fragment ions.

The FAB ion source consists of a cold cathode release ion gun and a collision charge exchange chamber. Ar is ionized in the release ion gun to form Ar^+, and then Ar^+ forms a high speed Ar^+ ion beam under the action of the accelerating voltage and the focusing electrode. The charge exchange chamber is filled with Ar. When the ion beam enters the exchange chamber, the following reaction occurs:

$$<Ar^+> + Ar \rightarrow <Ar> + Ar^+$$

Speedy inert gas ion neutral speed change over neutral atom

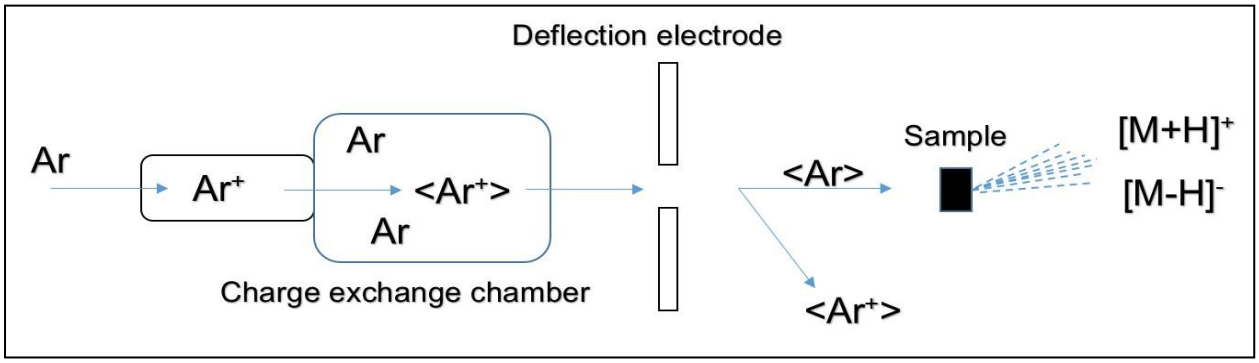




"< >" indicates a particle symbol with rapid directional motion. $<Ar+>$ is separated in the deflection electric field, and $<Ar>$ is still advancing at a high speed in the original direction, and finally hitting the sample target to ionize the sample:

$$<Ar> + M \rightarrow [M+H]^+ + [M-H]^- + Ar$$

The sample is dissolved in a solvent and applied to a tiny piece of metal in the FAB. The vapor pressure of the solvent used should be low enough to keep the sample in a dissolved state. The solvent used includes glycerin, diethanolamine, ethylene glycol, dimethyl sulfoxide or the like.



After the sample is ionized, its positive charge product is mostly present in the form of proton bonding or alkali metal ion binding. Generally only a small amount of alkali metal ions are needed, and a $[M+Na]^+$ or $[M+K]^+$ signal can appear in the mass spectrometer.

Advantages of FAB

- FAB is very effective for the analysis of non-volatile, thermally unstable polar compounds.
- It gives relative abundance of molecular ion.
- The ionization products [M+H]+ and [M-H]- are produced in pairs in FAB, facilitating the analysis of positive ion mass spectrometry and negative ion mass spectrometry.
- The FAB has high sensitivity and consumes fewer samples.
- For biologically active substances, the residual sample remains active and can be recycled due to the bombardment of the neutral particles used.

- In addition, the ionization probability and detection sensitivity of each component in the sample are related to the sample composition.
- If the energy required for ionization of one component is lower than the other components in the sample, the ionization probability of the component is large.

Disadvantages of FAB

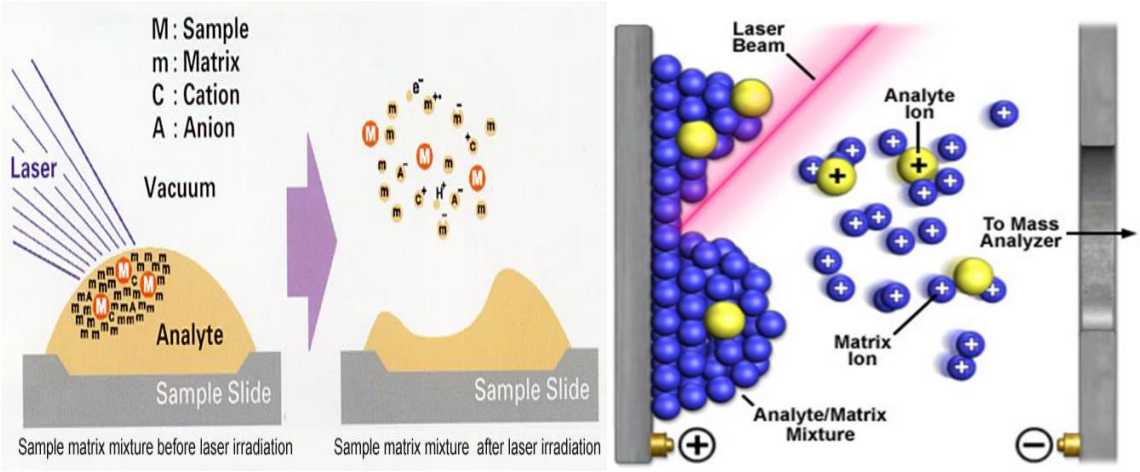
- FAB is not suitable for separating samples.
- Solvent used for the preparation of matrix may also ionized and observed in mass spectrum.
- It is difficult for FAB to separate the sample with low affinity proton abilities from samples with high affinity proton abilities.
- Moreover, for samples of mixtures of different volatility, FAB cannot fractionate and ionize the components.

One mark question answer

Sr No.	Question	Answer
1	Full form of CI in mass spectrometry	Chemical ionization
2	Full form of FAB in mass spectrometry	Fast atom bombardment
3	What is used as reference material in case of CI in mass spectrometry	Low molecular weight gases
4	CI is ____types ionization technique of mass spectrometry	Soft ionization technique
5	In FAB _____inert gas used for reference material	Ar

Matrix-assisted laser desorption ionization (MALDI)

- Matrix-assisted laser desorption/ionization (MALDI) is a technique to allows the high molecular weight compounds such as organic macro molecules and labile bimolecular into the gas phase as intact ions.
- MALDI is one of the recent developments of soft ionization techniques in the field of mass spectrometry.
- It can desorb intact analyte molecular ions with relative masses up to 300KDa.
- In MALDI-MS analysis, the analyte (sample) is first co-crystallized with a larger excess of a matrix compound (2,4-dihydroxybenzoic acid (DHB), 2,4-dimethoxy cinnamic acid, Sinapic acid etc).
- The matrix solution prepared in organic or water solvent is mixed with the analyte (e.g. protein-sample).
- A mixture of water and organic solvent allows both hydrophobic and water-soluble (hydrophilic) molecules to dissolve into the solution.
- This solution is spotted onto a MALDI plate (usually a metal plate designed for this purpose).
- The solvents vaporize, leaving only the recrystallized matrix, but now with analyte molecules embedded into MALDI crystals. The matrix and the analyte are said to be co-crystallized.
- Co-crystallization is a key issue in selecting a proper matrix to obtain a good quality mass spectrum of the analyte of interest.
- After that the prepared matrix was subjected for laser radiation results in desorption of the matrix as a plume.
- This plume carried analyte molecule in gas phase along with positive and negative ions.
- Thus the matrix plays a key role by strongly absorbing the laser light energy and causing, indirectly, the analyte to vaporize.
- The matrix also serves as a proton donor and acceptor, acting to ionize analyte in both positive and negative ionization modes, respectively. The TOF analyzers are typically used with the MALDI ionization source.



MALDI Advantages

- Soft Ionization technique
- Lower molecular fragment ion or even no molecule fragmentation
- High molecular weight analyte can be ionized easily
- Molecule need not be volatile
- The molecule have high molecular weight can also analysed under this technique

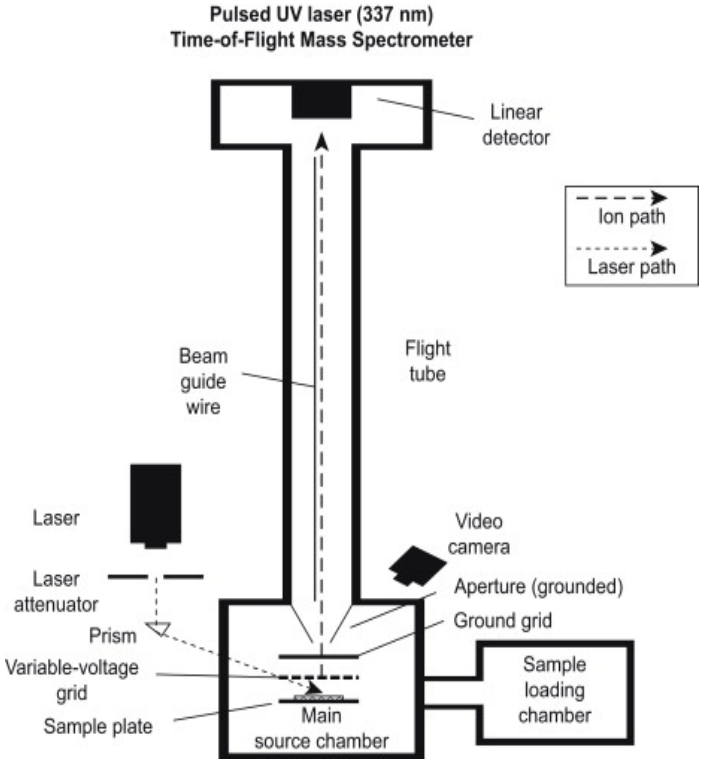
MALDI Disadvantages

- MALDI matrix cluster ions obscure low m/z species (<600)
- Signal reproducibility is low i.e. the mass spectrum obtained is not reproducible
- Coupling MALDI with chromatography can be difficult

Laser Desorption Ionization

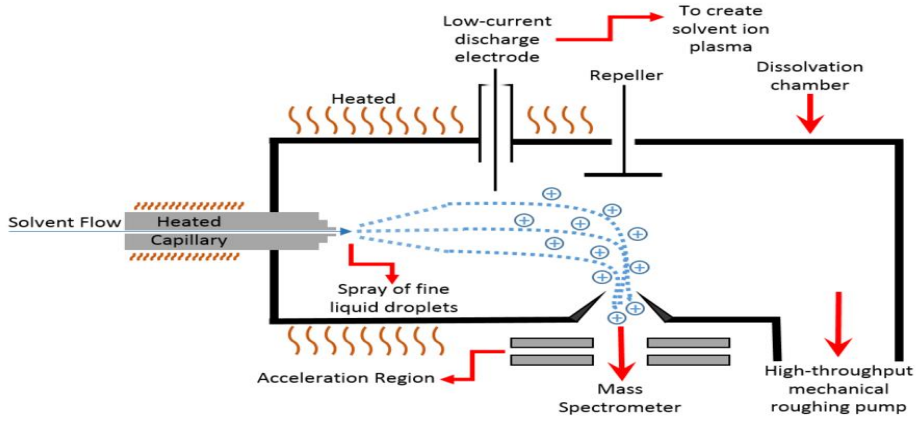
- Laser desorption (LD) ionization is a convenient technique for the study of molecules that are not soluble in common solvents.
- The sample is coated onto the surface of a metallic target rod, which is subsequently irradiated with a pulsed laser.

- The sample molecules on the surface desorb and gain or lose electrons to form charged species.
- That process achieves the goal of converting the sample in to gas-phase ions, as required for analysis by mass spectrometry.
- Low laser power is generally used to simply desorb a sample from the surface of a target rod.
- Alternatively, high energy laser can completely vaporize the target rod material itself to spontaneously create new clusters of atoms or molecules.
- The surface of the rod heats up to 5000 °C or greater, and that extreme temperature jump causes gaseous atoms and ions to be directly evaporated from its surface.
- At the same time, a pulse of inert helium gas flows over the rod and serves to carry the vapor into a growth channel.
- The ions must collide many times with the non-reactive helium gas. Those collisions rapidly cool all of the highly energetic gaseous atoms and ions.
- Moreover, as the gas cools, the ions originally evaporated from the rod begin to react to create strange and exotic clusters of atoms or molecules.



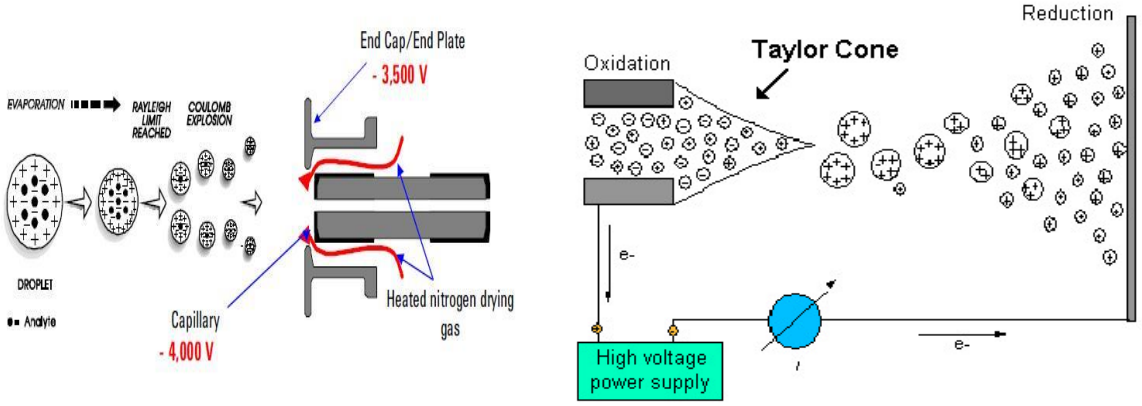
Thermo spray Ionization

- Thermospray is a soft ionization technique.
- In this method solvent flow of liquid sample passes through a very thin heated column to become a spray of fine liquid droplets.
- The nebulization is accomplished by pumping a liquid sample at moderately high pressure through an electrothermally heated capillary tube.
- Upon exiting the heated capillary, the rapidly expanding sample vapor converts the remaining liquid stream to an aerosol.
- As a form of atmospheric pressure ionization in mass spectrometry these droplets are then ionized via a low-current discharge electrode to create solvent ion plasma.
- A repeller then directs these charged particles through the skimmer and acceleration region to introduce the aerosolized sample to a mass spectrometer.
- It is particularly useful in liquid chromatography-mass spectrometry.



Electron spray Ionization ESI

- ESI technique involves spraying of a solution of the sample through a highly charged needle called ESI capillary which is at atmospheric pressure.
- The spraying process can be streamlined by using a nebulizing gas.
- The charged droplets are produced in which the positive or negative ions are solvated with solvent molecules.
- The liquid pushes itself out of the capillary as a mist or aerosol of fine charged droplets.
- These charged droplets are then passed through desolvating capillary where the solvent is evaporated in the vacuum and attachment of charge to the analyte molecules takes place.
- Desolvating capillary uses warm nitrogen as nebulising gas.
- The desolvating capillary is maintained under high pressure.
- As the droplets evaporate the analyte molecules comes closer together.
- These molecules become unstable as the similarly charged molecules come closer together and the droplets explode once again. This is referred as Coulombic fission.
- The process repeats itself until the analyte is free from solvent and is lone ion.
- The ion then moves to the mass analyzer.



- ESI can produce singly or multiply charged ions.

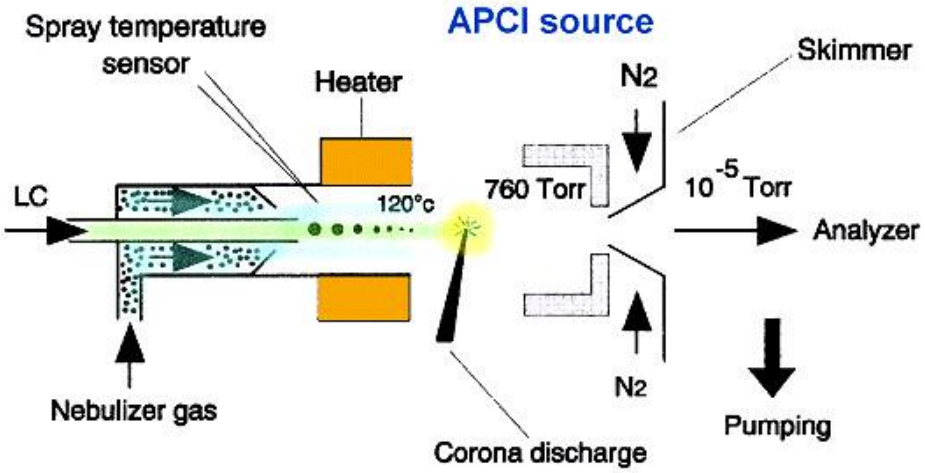
- The number of charges retained by a particular analyte depends on several factors such as the size, chemical composition, and higher order structure of the analyte molecule, the solvent composition, the presence of co-solutes, and the instrument parameters.
- For small molecules (< 2000 Da) ESI typically generates singly, doubly, or triply charged ions, while for large molecules (> 2000 Da) ESI can produce a series of multiply charged ions.
- ESI is very suitable for a wide range of biochemical compounds including peptides and proteins, lipids, oligosaccharides, oligonucleotide, bio-organic compounds, synthetic polymers, and intact non-covalent complexes.

ADVANTAGES

- Most important techniques for analysis of high molecular weight biomolecules such as polypeptides, proteins, oligonucleotides and synthetic polymers.
- Can be used along with LC and capillary electrophoresis.

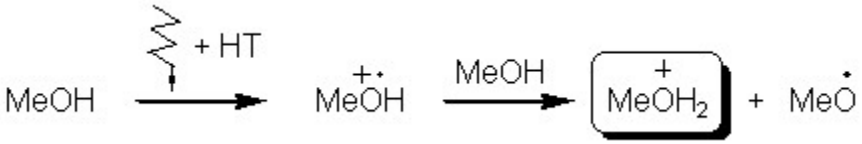
Atmospheric Pressure Chemical Ionization APCI

- APCI has also become an important ionization source because it generates ions directly from solution and it is capable of analyzing relatively non-polar compounds.
- Similar to electrospray, the liquid effluent of APCI is introduced directly into the ionization source through APCI probe.
- Sample solution undergoes nebulization to form an aerosol spray of fine droplets.
- It is rapidly heated in a stream of nitrogen desolvation gas before emerging from the probe as a stream of desolvated/vaporized sample plume.
- The electric field is sufficiently strong to ionize solvent vapour by either removal (positive ion mode) or donation (negative ion mode) of an electron.
- Solvent/Reagent ions are formed in the region of the corona discharge needle.
- These ions react with analyte molecules to form singly charged protonated or deprotonated analyte ions.

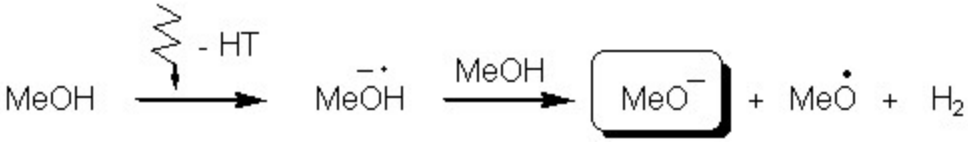


According to mechanisms both type ions are produced during the ionization.

Positive In AP-CI



Negative In AP-CI



Later these ion molecules react with analyte molecule to give positive and negative ions.

- The sample ions are then accelerated out of the atmospheric pressure source and into the mass analyzer by application of a small voltage (typically 20-70 V) to the skimmer cone.

- The pressure differential between source and analyzer regions is maintained by the presence of an area of intermediate vacuum.
- During the ionization process itself, little energy is transferred to the sample molecule, and fragmentation is minimal.

Atmospheric Pressure photon Ionization APPI

- APPI also one of the atmospheric pressure ionization (API) technique used in mass spectrometry.
- It is good for low to moderately polar compounds like polycyclic aromatics, steroids, some mycotic toxins etc.
- APPI is relatively less popular ionization technique for LCMS instruments when it compared with ESI and APCI.
- In this technique sample first vaporized by nebulizer of liquid solution
- In APPI technique samples are ionized by using UV light, molecules interacted with photon beam of UV light.
- Analyte molecules (A) absorb a photon (hv) and become an electronically excited molecule.
- If the ionization energy (IE) of analyte molecules is lower than the energy of photon, then the analyte molecule releases energetic electron and become the radical cation.

According to the path of ionization, this techniques divided in to three types.

1) Direct ionization
2) Indirect ionization
3) Dopant ionization APPI

Direct ionization

In this method, the analyate (A) molecule directly reacts with photon become excited.

The excited molecule later ionized into an ion by loss of electron.

$$A + hv \rightarrow A^*$$

$$A^* \rightarrow A^{+\cdot} + e^- \quad (IE < hv)$$

Indirect ionization

In this method, the sample molecule does not show absorbance of photon of UV light region but solvent molecule is highly UV active.

Hence, first of all solvent molecules absorb photon and become excited.

These molecules then react with sample molecule to give corresponding ions.

$$S + hv \rightarrow S^*$$

$$S^* \rightarrow S^{+\cdot} + e^-$$

$$S^{+\cdot} + A \rightarrow S^{\cdot} + A^+$$

Dopant ionization APPI

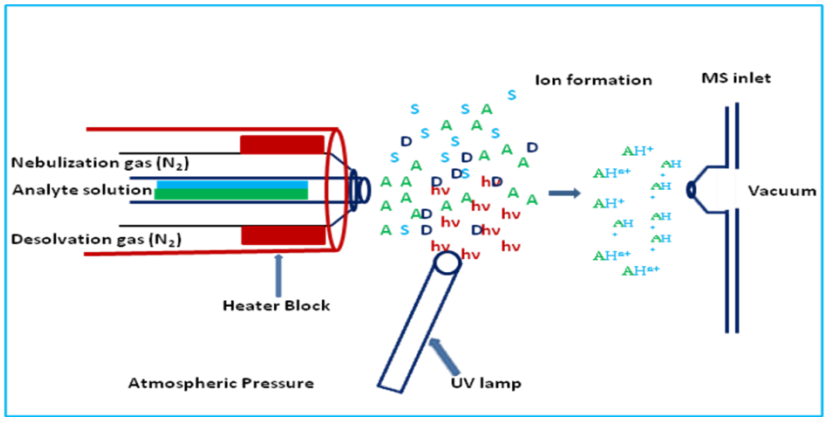
- Sometimes, solvent and sample molecules are UV in active and hence they give not absorbance of photon.
- In this condition some UV active compounds are added in ionization chamber which is shows absorbance of photon.
- As a medium for photoionization, the dopant helps the analyte to form ions mainly by exchanging charge or proton transfer.
- The ionized dopant ions (D+) can exchange charge directly with the analyte to form M+.
- On the other hand, the D+ can also transfer the obtained positive charge to the solvent, and then the protons are transferred to the analyte by the solvent, thereby forming enough [M + H]+ to enter the mass spectrometer.
- It can be known from the DA-APPI process that the two basic conditions as a dopant are that the ionization potential is lower than the energy of the photon emitted by the light source and the proton affinity is low.

$$D + hv \rightarrow D^+.$$

$$D^+. + A \rightarrow D + A^{+\cdot} \quad \text{if } EA_A > EA_D \text{ (Electron affinity)}$$

$$D^+. + S \rightarrow [D\text{-}H]^{\cdot} + [S+H]^+ \quad \text{if } PA_S > PA_D \text{ (Proton affinity)}$$

$$[S+H]^+ \rightarrow S \quad + \quad [A+H]+ \qquad \text{if } PA_A > PA_S$$



Advantages of APPI

- APPI has significant analytical advantages for compounds, particularly weakly polar and non-polar compounds.
- It can be used to analyze drugs, drug products, peptidoglycans, polycyclic aromatic hydrocarbons, steroids, mycotoxins, quinine, acetaldehyde, ketones, and so on.
- APPI can simultaneously ionize polar and non-polar small molecules, allowing users to analyze more compounds in a single pass.
- At the same time, APPI greatly reduces the matrix effect and relative ion inhibition during the measurement process, which simplifies the sample purification process, saves the sample pretreatment time, obtains better analyte recovery rate, and ensures the quality of analysis data.
- Moreover, the measurement results of APPI have a dynamic linear range of 5 orders of magnitude, which is the preferred ion source method for quantitative analysts.

Disadvantages of APPI

- APPI is less sensitive than atmospheric pressure chemical ionization.
- APPI is not suitable for compounds with poor thermal stability.
- In the actual analysis, the amount of ions generated by direct photoionization of some analytes is small, so the dopant is indispensable for APPI.