JOURNAL OF PHARMA INSIGHTS AND RESEARCH

SHORT COMMUNICATION

A Review on Gas chromatography – Mass spectroscopy

Sharma S.S.S.M[1], Vaishnavi Atyam*[2], Mahalakshmi Avidi[2], Deekshitha Ayinala[2]

[1] *Asst Professor, Sri Vasavi Institute of Pharmaceutical Sciences, Pedatadepalli, Andhra Pradesh, India*
[2] *Student, B.pharmacy, Sri Vasavi Institute of Pharmaceutical Sciences, Pedatadepalli, Andhra Pradesh, India*

Publication history: Received on 7thJanuary; Revised on 25th January; Accepted on 30thJanuary

Article DOI: 10.5281/zenodo.10614850

Abstract: Gas Chromatography- Mass Spectrometry (GC-MS) is an analytical method that combines the features of gas chromatography and mass spectrometry. As the name suggests, it is essentially a single method of assessing chemical mixtures that combines two methodologies. It is among the most precise instruments available for examining environmental sample data. Both the qualitative identification and the quantitative measurement of individual components in complicated mixtures are accomplished with GC-MS. The most developed chromatography mass spectrometry coupling method, GC/MS, can be used to analyse metabolites that are volatile after derivatization, have low polarity, or have a low boiling point. Applications of GC-MS include identification of unknown samples, academic research, drug detection, fire and explosives investigation, disease diagnostics, and astrobiology. Materials that were previously believed to have decomposed beyond recognition can have trace elements identified in them. A few examples demonstrate how GC-MS is a useful and complementary tool for many field investigations involving the identification and quantification of organic compounds. The purpose of this article is to discuss several GC-MS elements, including concept, instrumentation, applications, and advantages.

Keywords: Gas chromatography; Mass spectroscopy; Analytical chemistry; Identification; Quantification.

1. Introduction

Gas chromatography (GC) is a type of chromatography where the stationary phase is a microscopic layer of liquid or polymer on an inert solid support, inside glass or metal tubing, called a column, and the mobile phase is a carrier gas, typically an inert gas like helium or an un-reactive gas like nitrogen [1-3]. The stationary phase in the capillary column is a fine solid support that has been covered in a nonvolatile liquid. The stationary phase may exist within the solid itself. A stream of helium gas moves the sample up the column. Because some components of a sample take longer than others to move through the column, the components are kept apart. Mass Spectrometry (MS) uses a mass spectrometer (MS) as the GC's detector. Ionisation breaks up the sample as it leaves the GC column, and the broken pieces are sorted by mass to create a fragmentation pattern. Similar to retention time (RT), a sample's fragmentation pattern is exclusive to a given component and serves as that component's distinguishing feature. Because of its extreme specificity, it is frequently called the molecular fingerprint. The analytical technique known as gas chromatography-mass spectrometry (GC-MS) combines the capabilities of mass spectrometry and gas-liquid chromatography to identify various compounds present in a test sample. GC has excellent resolution in separating volatile and semi-volatile chemicals, but it is unable to identify them [4-7]. Most compounds can be precisely identified using the extensive structural information that MS can provide, but it is not able to easily separate them. The main aim of this review article is to discuss several GC-MS elements, including concept, instrumentation, applications, and advantages

2. Principle

2.1. Gas Chromatography

In analytical chemistry, gas chromatography is a popular form of chromatography that is used to separate and analyze molecules that can evaporate without breaking down. It is the most effective and useful separation method for intricate combinations of volatile substances. In gas chromatography, the analyte is carried through a column that is packed or coated with a stationary phase by means of a gaseous mobile phase, also known as an eluent. A few GC columns have lengths of up to 100 meters. In gas chromatography, the stationary phase is often a packing of inert, small-diameter particles (like diatomaceous earth) with a liquid coating that is either nonpolar or limited to the inner surface of the column. This liquid has a 0.1–5 μm thin layer. An inert gas, such as nitrogen, argon, or helium, is the mobile phase; it solely moves the analyte molecules down the column [8-10]. The analyte and column packing material don't interact with the carrier gas. About 90% of instruments still utilize helium as their primary carrier gas, even though hydrogen is recommended for better separations. The chromatography column is a long, tubular apparatus into

* Corresponding author: Vaishnavi Atyam

which the sample is introduced. Because some drugs take longer than others to move through the column, they are segregated from one another in a sample [9-11]. The length of time an analyte spends in the stationary phase as opposed to the mobile phase determines its retention time (the amount of time it takes to transit through the column); greater retention durations are associated with analytes whose polarity are more similar to those of the stationary phase

2.2. Mass Spectrometer

An analytical method called mass spectrometry (MS) ionizes chemical species and sorts the ions according to their mass-to-charge ratio. The masses in a sample are measured via a mass spectrum. Mass spectrometry is applicable to both complicated mixtures and pristine samples in a wide range of fields. An ion source, a mass analyzer, and a detector are the three components of a mass spectrometer. Some of the sample is transformed into ions by the ionizer [12, 13]. Numerous ionization procedures exist, based on the sample's phase (solid, liquid, or gas) and the effectiveness of different ionization mechanisms for unidentified species.

When an ion travels past or collides with a surface, the detector captures the current or charge that is generated. Although Faraday cups and ion-to-photon detectors are also used, electron multipliers of some kind are usually employed. Modern commercial devices frequently use micro channel plate detectors. Rather than the molecular weight of the neutral species, the mass spectrum shows the mass to charge ratio of the ions [14].

3. Instrumentation

The instrumentation of the GC-MS consists of carrier gas, injector, column, column oven, detectors and mass spectrometer

3.1. Carrier gas

Carrier gas is supplied to the device via tubing, regulators, and cylinders. To guarantee high gas purity and gas supply pressure, it is customary to purify the gases. For hydrocarbon applications, helium is typically utilized as the carrier gas; however, depending on the application, nitrogen, argon, and hydrogen may also be used. A carrier gas needs to be chemically inert, dry, and oxygen-free [15].

3.2. Injector

The gas that results from volatilizing the sample is entrained into the carrier stream that enters the GC column in this instance. The sample injection valve is opened and the carrier gas is changed to force the sample into the first column and out of the sample loop in order to introduce it into the analytical flow path. [16-18]

3.3. Column

Gas chromatography uses hollow capillary columns with the stationary phase coated onto the inner wall or columns packed with coated silica particles to transfer sample components. The gas mixture is separated into its constituent parts by the columns based on a physical property. Lower boiling point components flow through the column more slowly than higher boiling point components do. This is because of their relative motion [10]. The column's temperature affects how quickly this separation happens. The degree of separation between the components is determined by the column's length of the column determines the amount of separation of the components. While packed GC columns typically have an internal diameter of 2 or 4 mm and range in length from 1 to 5 meters, capillary GC columns are typically several meters long (10-120 m is normal). The amount of substances dispersed in the gas phase and stationary phase, or the β value (the distribution ratio of substance between the two phases), is determined by the diameter of the capillary column and the thickness of the stationary phase. Thin-film columns are useful for the analysis of less volatile chemicals with high boiling points, while thick-film stationary phase columns (low β value) are usually employed for the study of volatile compounds [19]

3.4. Detectors

The components travel over the detector following their separation by the chromatograph columns. The instrument at the end of the column called the detector measures the mixture's constituent parts quantitatively as they elute together with the carrier gas. There are a number of detector types for gas chromatographs, such as flame ionization detectors for ppm-level hydrocarbons and flame photometric detectors for ppb- to ppm-level sulphur detection. However, the thermal conductivity detector (TCD) is the most widely used detector for hydrocarbon gas measurements. The GC Chemiluminescence Detector, Atomic Emission Detector, and Electron-Capture Detector are the other detectors [20]

3.5. Column Oven

The temperature of the gas chromatographic ovens can be programmed; they can normally be set between 50 and 400°C, but with cryogenic cooling, they can drop as low as -25°C. The oven's internal temperature is kept extremely constant by shielding its

components from the effects of outside temperature fluctuations [21]. The application determines the temperature at which the oven is set: the higher the predicted hydrocarbon mixture, the hotter the oven temperature. Typical oven temperatures for natural gas applications.

3.6. Mass spectrometer

The mass spectrometer uses electrical and/or magnetic fields to distinguish between the phase ions in order to separate them. If the atom or molecule is first converted into an ion, magnetic fields have the ability to deflect atoms and molecules. [21] The instrumentation of the GC-MS is shown in Figure 1 below:

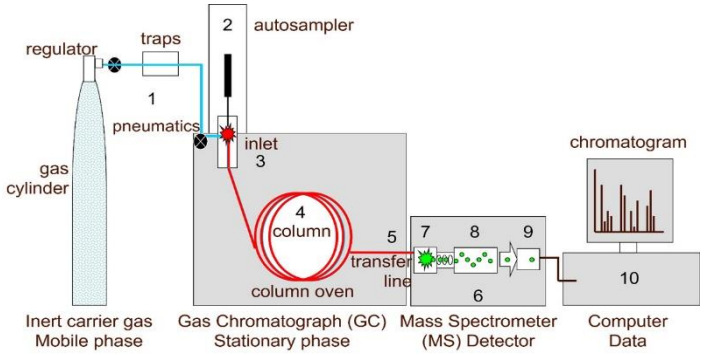

Figure 1 Instrumentation of GC-MS

4. Applications

The applications [18-21] of GC-MS are:

- Detection of illnesses in bodily fluids.
- Identification of congenital illnesses and conditions.
- Detection of pulmonary tuberculosis indicators in human breath.
- Characterization of candidate compounds in drug development.
- Examination of clinical trial drug behavior.
- Quality control in the pharmaceutical industry.
- Screening for congenital metabolic disorders through urine analysis.
- Monitoring environmental contaminants in soil, water, and air.
- Identification of contaminants in active medicinal components.
- Evaluation of aromatic molecules in food and beverage ingredients.

5. Conclusion

A common method in many fields of research and technology is gas chromatography (GC). An extensive and multifaceted analytical space is made possible for the study of complex mixtures with high sensitivity, selectivity, and specificity by the combination of separation and mass spectrometric techniques. GC-MS provides increased sensitivity, faster analysis, and increased confidence in sample identification—especially for chemicals that are challenging to evaluate. In toxicology, forensics, food science, academic research, organic chemical detection, and environmental research, it is frequently the preferred analytical technique. It has several instrument contents as well as some methodologies.

References

[1] Pankaj T, Upasana T, Pooja K, Amar D A, Pramod K, Aman K, &Mahendra Singh A, —A Review on GC-MS Hyphenated Technique.‖ Asian journal of pharmaceutical analysis, 2021, 11(4), 285-292.

[2] Ashish C, Manish K G and Priyanka C, -GC-MS Technique and its Analytical Applications in Science and Technology.‖ Analytical & bioanalytical techniques, 2014, 5(6), 1-5.

[3] Dong-liang lin, Sheng-meng wang, Chihhung wu, Bud-gen chen and Ray H Liu, chemical Derivatization for the Analysis of Drugs by GC-MS — A Conceptual review‖. Journal of Food and Drug Analysis, 2008, 16(1), 1-10.

[4] Sathe K P, Khedkar A N and Sathe M P, —A review on gas chromatography-mass spectrometry. —World Journal Of Pharmaceutical Research, 2021, 10(3), 741-763

[5] Lakshmi himabindu M, Angala P, Gopinath C, —A Review on GC-MS and Method Development and Validation.‖ International Journal of Pharmaceutical Quality Assurance 2013, 4(3), 42-51.

[6] Arji SR, Eranki SS, Pecchetty S, Sarella PN. Unconventional stationary phases: Nanomaterials, nanoparticles and the future of liquid chromatography.

[7] Bhavyasri K, Samreen B, Mogili S, —2- Dimensional Gas Chromatography-Mass Spectroscopy: A Review.‖ International Journal of Pharmaceutical Sciences Review and Research, 2022, 76(1), 140-150

[8] D.R. Jenke, "Chromatographic Method Validation: A review of Current Practices and Procedures. I. General Concepts and Guidelines", J. Liq. Chrom. And Rel.Technol., vol. 19 (1996), pp. 719-736. SWGDRG, Quality Assurance/General Practices Recommendations, 2008.

[9] Harani A, VijayaRatnam J, Dipankar B, Kumar DS, Lalitha MB, Kumar SP. Molecular interaction studies of phosphatidylcholine as drug delivery substrate for asenapine maleate. Current Science. 2018 Aug 10;115(3):499-504.

[10] International Organization for Standardization, ISO 9000:2000 Quality management systems—Fundamentals and vocabulary.

[11] International Organization for Standardization/International Electrotechnical Commission, ISO/IEC 17025:2005 General Requirements for Competence of Testing and Calibration Laboratories, paragraphs 5.5-5.6.

[12] Arji SR, Eranki SS, Kadimi A, Sarella PN, Mangam VT. Development and validation of an HPLC method for the simultaneous estimation of salbutamol, theophylline and ambroxol in tablet dosage form. International Journal of Science and Research Archive. 2023;10(2):634-45.

[13] Stein, SE; Scott DR (1994). "Optimization and testing of mass spectral library search algorithms for compound identification". J Am Soc Mass Spectrom 5(9): 859–866.

[14] Amirav, A.; Gordin, A. Poliak, M. Alon, T. and Fialkov, A. B. (2008). "Gas Chromatography Mass Spectrometry with Supersonic Molecular Beams". Journal of Mass Spectrometry 43: 141–163.

[15] Alon, T.; Amirav, A. (2006). "Isotope Abundance Analysis Method and Software for Improved Sample Identification with the Supersonic GC-MS". Rapid Communications in Mass Spectrometry 20: 2579–2588.

[16] Robert P., Dr Adams (2007). Identification of Essential Oil Components By Gas Chromatography/Mass Spectrometry. Allured Pub Corp. ISBN 1-932633-21-9.

[17] Adlard, E. R.; Handley, Alan J. (2001). Gas chromatographic techniques and applications. London: Sheffield Academic. ISBN 0-8493-0521-7.

[18] Eugene F. Barry; Grob, Robert Lee (2004). Modern practice of gas chromatography. New York: WileyInterscience. ISBN 0-471-22983-0.

[19] Eiceman, G.A. (2000). Gas Chromatography. In R.A.Meyers (Ed.), Encyclopedia of Analytical Chemistry: Applications, Theory, and Instrumentation, pp. 10627. Chichester: Wiley. ISBN 0-471-97670-9

[20] McEwen, Charles N.; Kitson, Fulton G.; Larsen, Barbara Seliger (1996). Gas chromatography and mass spectrometry: a practical guide. Boston: Academic Press. ISBN 0-12-483385-3.

[21] Niessen, W. M. A. (2001). Current practice of gas chromatography–mass spectrometry. New York, N.Y: Marcel Dekker. ISBN 0-8247-0473-8

Author's short biography

Sharma S.S.S.M

Sharma S.S.S.M completed his M.Pharmacy in Pharmaceutical analysis and now, he is working as an Asst.professor in the Department of Pharmaceutical analysis & Quality Assurance, with three years experience

Vaishnavi Atyam

Vaishnavi Atyam is currently studying final year B.pharm. She is interested in the latest technology and novel trends in the pharma field

Mahalakshmi Avidi

Mahalakshmi Avidi is pursuing her final year B.pharm. She has immense interest in the latest development and technology in the pharma field.

Deekshitha Ayinala

Deekshitha Ayinala is currently studying final year B.pharm. She has an enormous interest in the pharma and medical research.