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A REVIEW ON GAS CHROMATOGRAPHY

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ABSTRACT

Gas chromatography is highly effective and versatile analytical technique with numerous scientific applications in field of science and technology. The applications of GC to a number of studies for determining organic compounds from around the world are presented and highlighted its universal use and acceptance. Many volatile and semi volatile compounds such as residual monomers, solvents and plasticizers and low molecular weight additives antifoaming agents can easily be analyzed by GC. GC is likewise utilized technique as a part of numerous environmental and forensic labs since it takes into consideration the detection of very small quantities. GC is sensitive, accurate, reproducible, quantitative and versatile tool well adapted for the analysis of complex mixture using various detectors. These techniques play an important role in analysis of drugs and pharmaceutical products. However, the use of GC is limited up to volatile and thermally stable compounds or the molecules that may undergo derivatization reactions to thermally stable products.

KEYWORDS: Gas chromatography, Analysis of complex mixtures, Detectors

INTRODUCTION

Gas chromatography has a very wide applications in different field. But, its first and main area of use is in the separation and analysis of complex mixtures such as essential oils, hydrocarbons and solvents.[1-3] Because of its sensitivity, simplicity as well as effectiveness in separation of components of mixtures, gas chromatography is one of the most important tools used in chemistry. It is widely used for the purification of compounds and the determination of such thermochemical constants such as vapor pressure, heats of solution and vaporization, activity coefficients. Intrinsically, with the use of the electron capture detector and the flame

ionization detector (which have very high sensitivities) in gas chromatography can quantitatively determine materials which are present at very low concentrations. It follows, that the second most important application of area is in forensic work, pollution studies and general trace analysis.[4-9]

Unlike most of the different types of chromatography, the mobile phase does not show interaction with molecules of analyte but only transport the analyte through the column.[10] Faster gas chromatographic separation of complex mixture is a generally beneficial option. Since the decrease time of analysis results in the increased sample throughput and consequently, the laboratory costs of operation can be reduced significantly. Reduction of analysis time can be achieved by changing in column parameters (smaller column inner diameter, shorter length, thinner film of stationary phase) or operational parameters (isothermal analysis, faster temperature program rate). Higher carrier gas flow rate, different carrier gas or a combination of both approaches can be applied.[11]

PRINCIPLE

The specimen arrangement is mixed into the instrument enters a gas stream which transports the sample into a division tube which is known as the "column." (Nitrogen or helium is used as carrier gas). The distinctive parts are secluded inside the section.[12-21] To quantify a sample with an obscure focus, a standard specimen with known concentration is mixed into the instrument. A gas chromatograph used for isolating chemicals in a complex mixture of sample. A gas chromatograph done the analysis through slender tube known as the column, through the column distinctive Chemical constituents of the sample go in a gas stream (portable stage, transporter gas) at various rates relying upon their different physical and chemicals properties and their interaction with a particular column filling material, called as stationary phase. As the chemicals are leave the end of the column, they are detected and analyzed electronically. The capacity of the stationary phase in the column is to isolate the different components, causing on every component to leave the segment at a different time (retention time). Different parameters that can be utilized to change the order or time of retention are the length of column, flow rate of carrier gas, and the temperature.[22-29]

In a Gas chromatographic analysis, a specific known volume of vaporous or fluid analyte is inserted into the "entrance" (head) of the column, generally by using a micro syringe.[30-36]

An indicator is utilized to monitor the outlet stream from the segment; in this way, the time at which each part achieves the outlet and the measure of that segment can be resolved. As a rule, Substances are recognized by the condition in which they rise (elute) from the area and by the retention time of the analyte in the section.[37-41] Complex samples like natural products extracts, biological samples etc. for these samples, headspace sampling is the fastest method for analyzing the volatile organic compounds.[42-43]

The basic principle of gas chromatography is that greater the affinity of the compound for the stationary phase, more the compound will be retained by the column and longer time will be required for elution and detection. Thus, the heart of the gas chromatograph is the column in which the separation of the component takes place and to this must be added the source and control of the carrier gas flow through the column, a mean of sample introduction and detection of the components as they elute from the end of the column. Since temperature will increases the volatility of the analytes, the column is placed in a thermostatically controlled oven.[44]

INSTRUMENTATION

PHYSICAL COMPONENTS OF GAS CHROMATOGRAPHY

1. Autosamplers
2. Inlets
3. Detectors

Auto samplers

The autosampler gives the way to insert a sample automatically into the channels. Manual insertion of the sample is possible but not more common. Programmed insertion gives good reproducibility as well as time-improvement.[45-50]

Inlets

The column injector or inlet gives the way to bring a sample into a continuous stream of carrier gas. The inlet is nothing but the piece of equipment appended to the column head. The common inlet sorts are: on- column inlet, S/SL (split/split less) injector, PTV injector, and Gas source inlet or gas switching valve, P/T (Purge-and-Trap) system.[51]

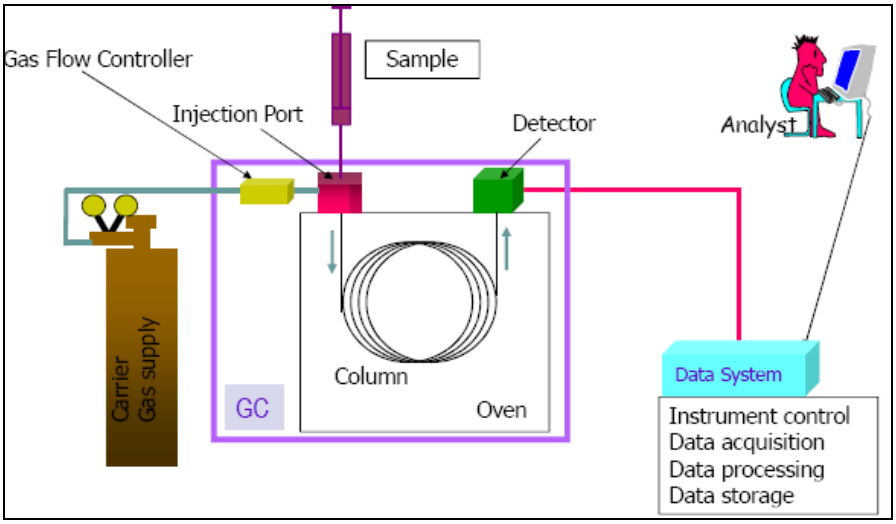

Fig no 01: Schematic representation of gas chromatography.

Split/Splitless Injector

When the splitter is installed or inserted in the front of the column, split injection can be adopted. To ensure a certain volume of sample, splitless injection is most commonly employed in Preparative GC.[52-54] The splitter installed behind the column allows the simultaneous collection and detection of the effluent.

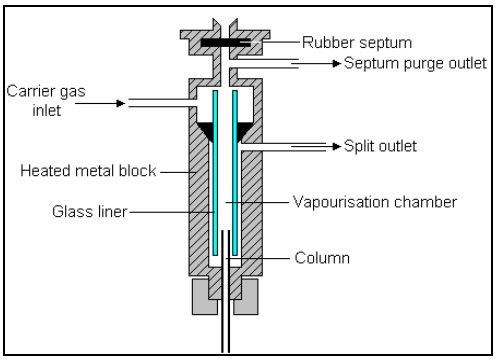

Fig no. 02.

Column

A column is of course, the central and starting piece of a chromatograph. An appropriately selected column can produce a good/efficient chromatographic separation which provides an accurate and reliable analysis. An optimized chromatographic separation begins with the column. The selection of the proper capillary column for any application should be based on four significant factors which are column internal diameter stationary phase, film thickness, and column length.[55] The loading quantity is considered to be one of the important key factors that affect the separation efficiency for GC. Therefore, special attention should be

paid to sample overloading, because this can result in less separation of the compounds or broader peaks that decrease the resolution.[57]

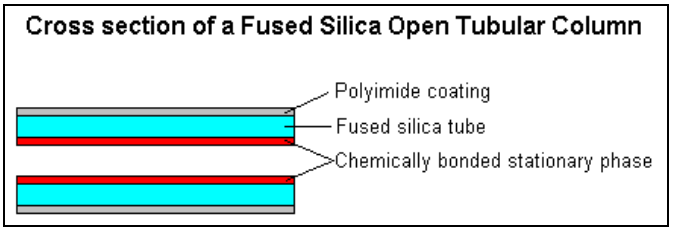

Fig no. 03.

Carrier Gas

Several inert gases can be used as the mobile phase or carrier gas of GC. Helium, Hydrogen and nitrogen are all common carrier gases. Each carrier gas has its own benefits and systems for which it is best suited.[56] The choice of carrier gas is important because it affects the separation efficiency in addition to the shapes and sizes of detector signals.[58,59] Nitrogen is a more suitable carrier gas for GC than helium and hydrogen, because of the high price of helium and the potential danger of hydrogen.[60]

Purge and Trap System

It means it is possible to take out volatile and semi volatile compounds from liquid or solid matrices by passing an inert gas over or through them and that the amount of material take out can be related to the inert gas passed through the matrices. This physical behaviour with the ability to trap the stripped materials on an inert trapping material affords an excellent opportunity for sample enrichment. The trap is usually allowed to come near to room temperature before to transfer of the analyte.[61]

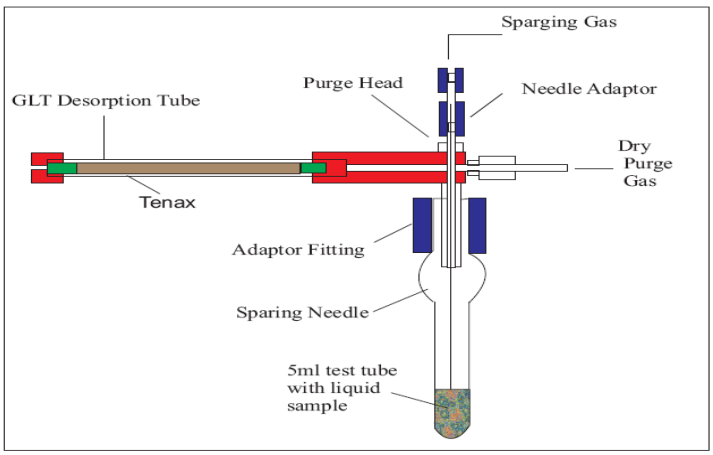

Fig no. 04: Diagram of purge-trap system.

DETECTORS

Detector temperatures and the relative flow rates of hydrogen, carrier gas and air into the detector are the key operating parameters. 13a series of standards is defined for evaluation of detector parameters such as noise, drift, sensitivity, dynamic range, linear range etc.[56]

Various types of detectors used in GC are as follows.

- Mass Spectrometer (GC/MS)
- Flame Ionization Detector (FID)
- Thermal Conductivity Detector (TCD)
- Electron Capture Detector (ECD)
- Nitrogen-phosphorus
- Flame photometric (FPD)
- Photo-ionization (PID)

Mass spectrometer (GC/MS)

Numerous GC instruments are combined with a mass spectrometer, which are very good blends. The GC isolates the all compounds from each other, while the mass spectrometer distinguishes them in view of their fragmentation pattern.[62-69]

Flame ionization detector (FID)

This detector is extremely sensitive towards organic atoms (linear range: 106-107, 10-12 g/s = 1 pg /s) yet relative insensitive for a couple of small molecules i.e., H2S, N2, CO2, NO_2, CO, H2O. The more number of carbon atoms are in the molecule, the more fragments are framed and the more delicate the detector is for this compound. Unfortunately, there is no relationship between the size of the signal and number of carbon molecules.[70] FID is typically used for organic compounds and used in analysis of pharmaceutical compounds and quality control.[56] Flame ionization detector (FID) i.e. destructive detectors most widely used, the splitter separates the gas flow and diverts a small part to the detector and the rest of the flow to the traps.[71]

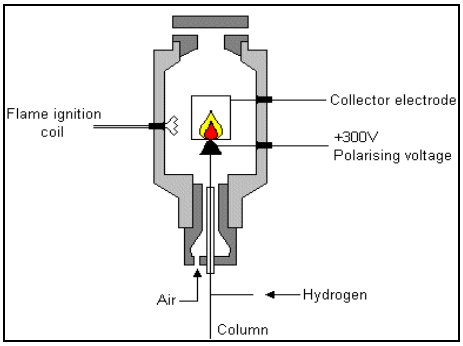

Fig no. 05.

Thermal conductivity detector

Thermal Conductivity Detector is less sensitive than the FID (straight range: 103-104, 10-5-10-6 g/s). The acknowledgment relies on upon the relationship between the two gas streams, one containing only the carrier gas, the containing the transporter gas and the compound. Really, a carrier gas with a more warm conductivity i.e., helium or hydrogen is used to amplify the temperature distinction (and along these lines the distinction in resistance) between two fibers (thin tungsten wires). The temperature distinction between the specimen's cell fibers and the reference is seen by a Wheatstone bridge circuit.[72-82] A backed-bed TCD with a short response time, which is less influenced by the carrier gas flow rate than conventional detectors.[83] Designed of conduit with copper jackets that was coupled to sources of thermal energy and joined within the TCD to minimized undesired condensation within the conduits.[84]

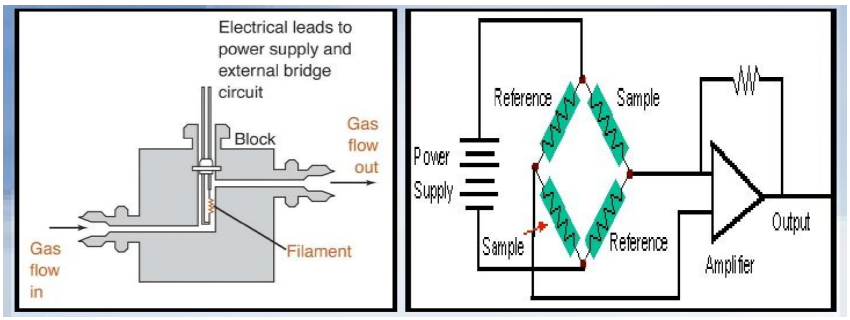

Fig no. 06.

Electron capture detector (ECD)

This detector comprises of a depression that contains a radiation source and two terminals that transmits -radiation (i.e., 63Ni, 3H). The impact amongst electrons and the carrier gas (methane in addition to an inert gas) results into a plasma-containing electrons and positive ions. On the off chance that a compound is available that contains electronegative molecules,

those electrons will be "caught" to frame negative particles and the rate of electron accumulation will diminish.[85] This indicator is every now and again utilized as a part of the investigation of chlorinated mixes i.e., pesticides (insecticides and herbicides,) polychlorinated biphenyls, and so forth for which it shows a high sensitivity.[86, 87]

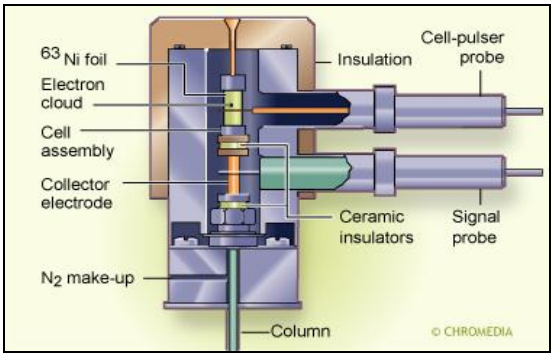

Fig no. 07

Nitrogen-phosphorus detector

Nitrogen-phosphorus detector is the type of thermionic detector where nitrogen and phosphorus change the work capacity on an uncommonly coated bead and a subsequent current is measured. Alkali Flame Detector, AFD or AFID and Alkali Flame Ionization Detector. AFD has high affectability to phosphorus and nitrogen, like NPD. Nonetheless, the alkaline metal particles are supplied with the hydrogen gas, instead of a bead over the fire. Consequently, AFD does not endure the "fatigue" of the NPD, but rather gives the information about a steady sensitivity over drawn out stretch of time.[88-91]

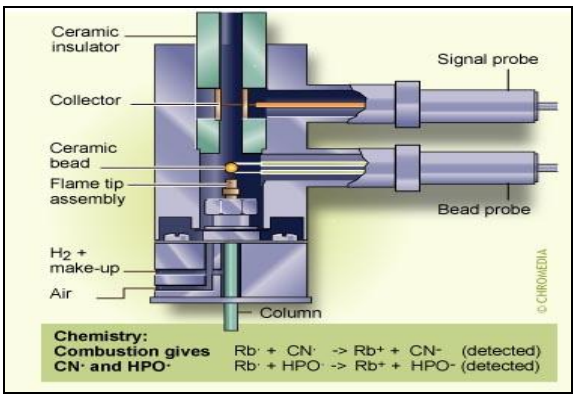

Fig no. 08

Flame photometric (FPD)

Flame photometric (FPD) is the important type of detector which utilizes a photomultiplier tube to identify spectral lines of the mixes as they are burned in a fire. Compounds eluting off

the column are conveyed into a hydrogen energized fire which excites particular components in the molecule, and the excited components (Halogens, P, S, and Some Metals) radiate light of particular characteristic wavelengths. The emitted light is separated and detected by a photomultiplier tube. Specifically, sulphur discharge at 394 nm and phosphorus emission is around 510-536 nm.[92-93]

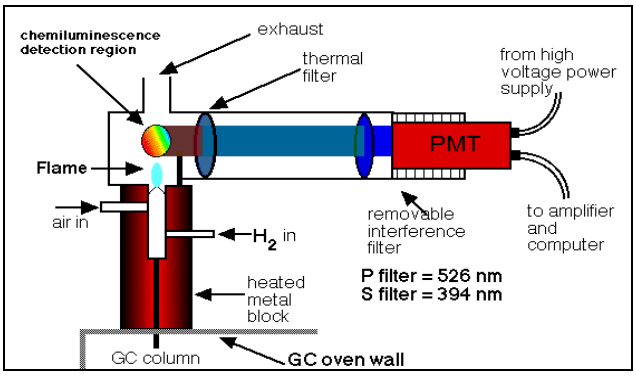

Fig no. 09

Photo-ionization detector (PID)

The Poly arc reactor is an additional to new or existing GC-FID instruments which progressions over each natural compound to methane atoms going before their recognition by the FID.[94-91] This framework can be used to upgrade the reaction of the FID and gives information about the recognition of various more carbon-containing mixes. The complete change of mixes to methane and the now indistinguishable reaction in the indicator moreover it additionally disclose of the prerequisite for alignments and gauges since response variables are all equivalent to those of methane.

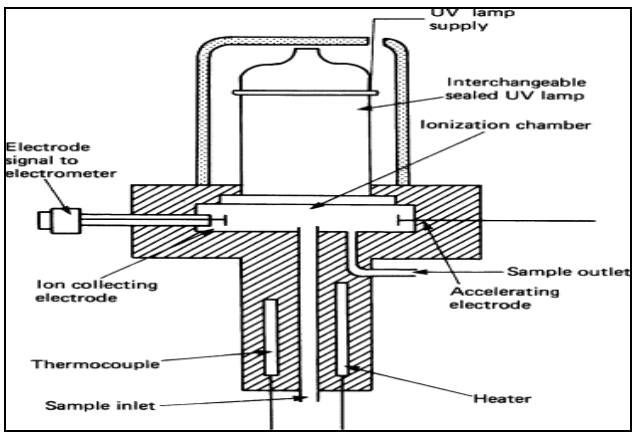

Fig no. 10

ADVANTAGES AND APPLICATIONS

- It is also commonly used in forensic toxicology to find steroids in biological specimens of suspects, poisons, victims, or the deceased.[100]
- GC-MS is also useful to detect and measure contaminants, spoilage and adulteration of oil, food, butter, ghee that could be harmful and should to be controlled and checked as regulated by governmental agencies.[101]
- For enhancing or increasing capability in homeland security and public health preparedness, traditional GC-MS units with the transmission quadrupoles mass spectrometer used.[102]
- Dozens of congenital metabolic diseases called as inborn error of metabolism are now a days detectable in newborn by screening tests using gas chromatography–mass spectrometry. GC can determine compounds in urine even in minor concentration.[103]
- GC is exclusively used in bio-analysis of blood, urine for the presence of narcotics, barbiturates, alcohols, residual solvents, drugs like anticonvulsant, anesthetics, antihistamine, and anti-epileptic.[104]

CONCLUSION

GC is an advanced technique that cannot be compared with other modern analytical equipment but can be complemented by mass spectrometer to achieve hyphenated technique such as GC-MS or MS. It has broad range of applications that serves to academic research, quality control as well as industrial applications. It's efficient, automated system provides fast, reproducible and effective results that serve as a important role in advancement of Science and Technology. This versatile analytical technique could be explored for better prospective in future.

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