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Gas chromatography

Introduction :

- Gas chromatography (GC) is one of the most versatile and ubiquitous analytical techniques in the laboratory. It is widely used for the determination of organic compounds.
- Although Martin and Synge invented liquid–liquid chromatography in 1941, the introduction of gas–liquid partition chromatography by James and Martin a decade later had a more immediate and larger impact for two reasons.
    - First, as opposed to manually operated liquid–liquid column chromatography, GC required instrumentation for application, which was developed by collaboration among chemists, engineers, and physicists; and analyses were much more rapid and done on a small scale.
    - Second, at the time of its development, the petroleum industry badly needed improved analytical monitoring and immediately adopted GC. Within a few short years, GC was used for the analysis of almost every type of organic compound.
- The recent technique of two-dimensional GC (also called GC-GC) has further improved these capabilities.
- In contrast to most other types of chromatography, the mobile phase does not interact with molecules of the analyte. The only function of the mobile phase is to transport the analyte through the column.
- More than 60 years after the award, GC systems are widely commercialized and used in various industries, capable of both of quantitation and qualification.

- Gas chromatography is one of the sole forms of chromatography that does not utilize the mobile phase for interacting with the analyte. The stationary phase is either a solid adsorbant or a liquid on an inert support.

Criteria for compounds to be analyzed by GC :

- **Volatility :**

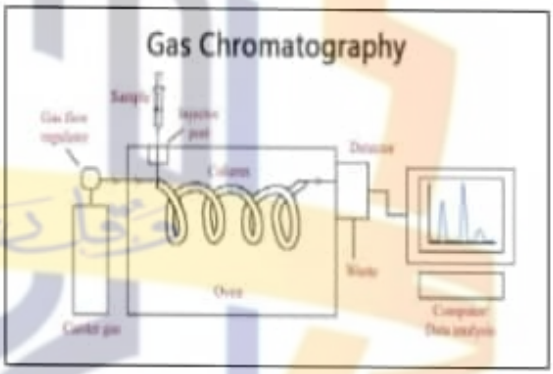
Unless a compound is volatile, it cannot be mixed with mobile phase, and therefore compounds that don't have volatile property, cannot be separated out.

- **Thermostability :**

The compounds which are in solid or liquid form, first need to be converted to gaseous form so they have to be heated to a higher temperature. At that temperature, the compounds have to be thermostable.

- The analyte should have a measurable vapour pressure at the temperature employed

Principle of gas chromatography :



The sample solution injected into the instrument enters a gas stream which transports the sample into a separation tube known as the "column." (Helium or nitrogen is used as the so-called carrier gas.) The various components are separated inside the column. The detector measures the quantity of the components that exit the column.

To measure a sample with an unknown concentration, a standard sample with known concentration is injected into the instrument. The standard sample peak retention time (appearance time) and area are compared to the test sample to calculate the concentration.

Gas chromatograph :

Gas chromatograph is an analytical instrument used to analyze the different components in a sample. An analytical method using a gas chromatograph is called gas chromatography (GC).

Definition of gas chromatography(GC) :

"Gas chromatography is a term used to describe the group of analytical separation techniques used to analyze volatile substances in the gas phase."

- In gas chromatography, the components of a sample are dissolved in a solvent and vaporized in order to separate the analytes by distributing the sample between two phases:
  - a stationary phase (liquid coated on a solid or a solid within a column)
  - a mobile phase (inert gas used as carrier)

- Based on stationary phase used in column, G.C is of 2 types :

a) Gas solid chromatography (GSC)
b) Gas liquid chromatography (GLC)

Gas solid chromatography (GSC) :

- Mobile phase – gas • Stationary phase – solid
- **GSC principle is ADSORPTION**
- GSC not used because of limited no. of S.P (stationary phase)
- In GSC, when a carrier gas containing analytes is passed through a column containing solid Stationary phase, the analytes get adsorbed on to the solid Stationary phase & the separation is due to differences in their adsorptive behavior.
- GSC finds application only in the separation & determination of low molecular mass gases such as air components, hydrogen sulfide, CO and nitrogen oxides.

Gas liquid chromatography (GLC) :

- Mobile phase – gas • Stationary phase – liquid
- **GLC principle is PARTITION**
- In GLC, when a carrier gas containing analytes is passed through a column containing liquid Stationary phase, the analytes get distributed themselves between the liquid Stationary phase & the carrier gas phase according to their partition coefficients.
- In GLC, Stationary phase is liquid that is retained/coated on the surface of an inert solid by adsorption or chemical bonding.
- In 1955, the first commercial apparatus for gas-liquid chromatography appeared on the market.
- GLC finds much greater application in the analysis of most of the organic compounds.

Similarities between Gas Liquid and Gas Solid Chromatography

- Both are Gas chromatographic techniques.
- Both uses gaseous mobile phase (usually an inert gas such as N, He etc.).
- Both are used for the separation of volatile compounds /mixtures.
- In both heat labile compounds cannot be separated.
- Both can be analytic or preparatory .
- Both types of GC use similar type of detectors.

Difference between gas liquid chromatography and gas solid chromatography

Gas solid chromatography	Gas liquid chromatography
In GSC, the stationary phase is in solid state	In GLC, the Stationary phase is in liquid state.
GSC is an adsorption chromatography technique.	GLC is a partition chromatography technique.

In GSC, the distribution coefficients of compounds are much higher	In GLC, the distribution coefficients are comparatively much smaller
The retention time (Rf) is comparatively long in GSC	The retention time is comparatively short in GLC.
No liquid phase is involved in GSC.	At least one liquid phase is involved in GLC.
Since liquid phase is absent in GSC, higher temperature can be used	The higher temperature in GLC is determined by the nature of liquid phase in the GLC.
Comparatively very small concentrations of samples can be used in GSC.	Higher concentrations of samples can be used in GLC.
GSC uses packed Columns.	GLC uses capillary columns.

How a Gas Chromatography Machine Works :

- First, a vaporized sample is injected onto the chromatographic column.
- Second, the sample moves through the column through the flow of inert gas.
- Third, the components are recorded as a sequence of peaks as they leave the column.
- Deals with both the stationary phase and the mobile phase.

Chromatographic Separation :

- In the mobile phase, components of the sample are uniquely drawn to the stationary phase and thus, enter this phase at different times.
- The parts of the sample are separated within the column.
- Compounds used at the stationary phase reach the detector at unique times and produce a series of peaks along a time sequence.
- The peaks can then be read and analyzed by a forensic scientist to determine the exact components of the mixture. Retention time is determined by each component reaching the detector at a characteristic time.

Instrumentation

It consists of:

1. Carrier gas tank
2. Flow regulators
3. Sample injection system
4. Column & Stationary phase
5. Detectors

Carrier gas system

- The main purpose of carrier gas is to transport sample components through the column.
- It determines the efficiency of the column, the time of analysis and the sensitivity of a given detector.
- Factors are considered while selecting a carrier gas :