A Brief Note On gas Chromatography

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Editorial

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DESCRIPTION

Gas Chromatography (GC) is a type of chromatography that is commonly used in analytical chemistry to separate and analyse compounds that can be vaporized without decomposition. GC is commonly used to test the purity of a specific substance or to separate the various components of a mixture. GC can be used in preparative chromatography to separate pure compounds from a mixture. Gas chromatography can also be referred to as Vapor-Phase Chromatography (VPC) or Gas–Liquid Partition Chromatography (GLPC). These alternative names, as well as their abbreviations, are commonly used in scientific literature.

Gas chromatography is the separation of compounds in a mixture by injecting a gaseous or liquid sample into a mobile phase, commonly referred to as the carrier gas, and passing the gas through a stationary phase. In most cases, the mobile phase is an inert or unreactive gas such as helium, argon, nitrogen, or hydrogen. The stationary phase is a microscopic layer of viscous liquid on a solid particle surface on an inert solid support inside a column of glass or metal tubing. In some columns, the surface of the solid particles may also act as the stationary phase.

A gas chromatograph is made up of a narrow tube known as the column, through which the vaporized sample is carried by a continuous flow of inert or nonreactive gas.

Components of the sample pass through the column at different rates, depending on their chemical and physical properties and the resulting interactions with the column lining or filling, defined as the stationary phase. Typically, the column is housed within a temperature-controlled oven. When the chemicals reach the end of the column, they are electronically detected and identified.

S/SL (split/split less) injector; a sample is introduced into a heated small chamber via a septum with a syringe – the heat aids in the volatilization of the sample and sample matrix. The carrier gas then sweeps the entire sample (split mode) or a portion of the sample (split mode) into the column. In split mode, the split vent exhausts a portion of the sample/carrier

gas mixture in the injection chamber. When working with samples with high analyte concentrations (>0.1 percent), split injection is preferred, whereas splitless injection is best suited for trace analysis with low analyte concentrations (0.01%). The split valve opens after a predetermined amount of time in splitless mode to purge heavier elements that would otherwise contaminate the system.

Gas source inlet or gas switching valve; gaseous samples in collection bottles are connected to a six-port switching valve, which is most commonly used. While a sample can be expanded into a previously evacuated sample loop, the carrier gas flow is not interrupted. The contents of the sample loop are inserted into the carrier gas stream upon switching.

An inert gas is bubbled through an aqueous sample, causing insoluble volatile chemicals to be purged from the matrix. At room temperature, the volatiles are 'trapped' on an absorbent column (also known as a trap or concentrator). The volatiles are then directed into the carrier gas stream after the trap is heated.

The selection of the carrier gas (mobile phase) is critical. In terms of efficiency, hydrogen has a range of flow rates comparable to helium. If flow rates are optimized, helium may be more efficient and provide the best separation. Helium is non-flammable and compatible with a wider range of detectors and older instruments. As a result, helium is the most commonly used carrier gas. However, the cost of helium has risen significantly in recent years, prompting an increasing number of chromatographers to switch to hydrogen gas. The continued preferential use of helium may be due to historical use rather than rational consideration.

The Flame Ionisation Detector (FID) and the Thermal Conductivity Detector are two commonly used detectors (TCD). While TCDs are advantageous in that they are non-destructive, their low detection limit for most analytes prevents their widespread use. FIDs are primarily sensitive to hydrocarbons, and are more sensitive than TCD. Because FIDs do not detect water or carbon dioxide, they are ideal for environmental organic analyte analysis. FID detects analytes two to three times more sensitively than TCD.

The TCD is based on the thermal conductivity of matter passing around a tungsten-rhenium thin wire with a current flowing through it. Helium or nitrogen serve as the carrier gas in this configuration due to their relatively high thermal conductivity, which keeps the filament cool while maintaining uniform resistivity and electrical efficiency. As analyte molecules elute from the column and mix with carrier gas, thermal conductivity decreases while filament temperature and resistivity increase, resulting in voltage fluctuations and, eventually, a detector response. Detector sensitivity is proportional to filament current and inversely proportional to the detector's immediate environmental temperature as well as the carrier gas flow rate.

Electrodes are placed adjacent to a hydrogen/air-fueled flame near the exit of the column in a Flame Ionisation Detector (FID), and when carbon-containing compounds exit the column, they are pyrolyzed by the flame. Due to the ability of carbons to form cations and electrons upon pyrolysis, which generates a current between the electrodes, this detector only works for organic/hydrocarbon containing compounds. The increase in current is translated into a chromatogram peak. FIDs have low detection limits (a few picograms per second), but they cannot produce ions from carbonyl-containing carbons. Helium, hydrogen, nitrogen, and argon are all FID compatible carrier gases.

Similar to NPD, Alkali Flame Detectors (AFD) or Alkali Flame Ionisation Detectors (AFID) have high sensitivity to nitrogen and phosphorus. However, rather than a bead above the flame, the alkaline metal ions are supplied with hydrogen gas. As a result, AFD does not experience the "fatigue" of NPD and instead provides consistent sensitivity over a long period of time. Furthermore, when alkali ions are not present in the flame, AFD behaves similarly to a standard FID. A Catalytic Combustion Detector (CCD) is a device that detects combustible hydrocarbons and hydrogen. To generate ions, a Discharge Ionisation Detector (DID) employs a high-voltage electric discharge.

The Flame Photometric Detector (FPD) detects spectral lines of compounds as they burn in a flame using a photomultiplier tube. Eluting compounds are carried into a hydrogen-fueled flame, which excites specific elements in the molecules, and the excited elements (P,S, Halogens, and Some Metals) emit light of specific characteristic wavelengths. A photomultiplier tube filters and detects the emitted light. Phosphorus emission, in particular, occurs at 510–536 nm, while sulphur emission occurs at 394 nm. A sample eluting from a column enters a chamber energised by microwaves that induce plasma with an Atomic Emission Detector (AED).