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CHE 532: Process Dynamics and Control II

**Assignment**

Describe, in detail, compare and contrast gas chromatography and gas chromatography-mass spectrometry

# Gas Chromatography (GC)

This describes the group of analytical separation techniques used to analyse volatile substances in the gas phase. Here, the components of a sample are dissolved in a solvent and vapourized in order to separate the analytes by distributing the sample between two phases: a stationary phase and a mobile phase. The mobile phase is a chemically inert gas that serves to carry the molecules of the analyte through the heated column. Gas chromatography does not utilize the mobile phase for interacting with the analyte. The stationary phase is either a solid adsorbent, termed gas-solid chromatography (GSC), or a liquid held on the surface and in the pores of a nominally inert solid support, termed gas-liquid chromatography (GLC), which is the more common technique (“Gas Chromatography,” n.d.).

In GSC the adsorbent may be alumina or silica. The advantages, such as cheapness and longevity, are insufficiently appreciated. The disadvantages, surface heterogeneity and irreproducibility, may be overcome by surface modification or coating with small amounts of liquid to reduce heterogeneity and increase reproducibility (Al-Thamir et al., 1977; Phillips & Scott, 1968). Porous polymers, for example, polystyrene and divinyl benzene, are also available. Molecular sieves are used mainly to separate permanent gases (Richardson et al., 2002).

The most commonly used support in GLC is diatomaceous silica, in the form of pink crushed firebrick, white diatomite filter aids or proprietary variants. Typical surface areas of 0.5 – 4 m2/g give an equivalent film thickness of 0.05 – 1 µm for normal liquid/support loadings of 5 – 50 % by mass (Richardson et al., 2002).

A basic (gas-liquid) chromatography instrument consists of (“Lab 5: Gas Chromatography/Mass Spectrometry (GC/MS),” n.d.):

1. A sample port or injector for introduction and vapourization of the sample;
2. A separating column, consisting of metal tubing packed with a solid material coated with a stationary absorbing liquid;
3. A carrier gas, usually Nitrogen or Helium, to sweep the sample through the column;
4. Flow control equipment to maintain a constant flow of carrier gas through the column;
5. The detector for measuring the quantity of a separated component;
6. Ovens and heaters for temperature control of the column, detector and injector;
7. An integrator or integrator/strip chart recorder combination to provide permanent record of the analysis.



Figure 1 Schematic diagram of a gas chromatograph

# Gas Chromatography-Mass Spectrometry (GC-MS)

As the name implies, this method combines the features of gas chromatography and mass spectrometry to identify different substances in a test sample (Sparkman et al., 2011). The GC-MS instrument separates chemical mixtures (the GC component) and identifies the component at a molecular level (the MS component). The GC works on the principle that a mixture will separate into individual substances when heated. The heated gases are carried through a column with an inert gas (such as helium). As the separated substances emerge from the column opening, they flow into the MS. Mass spectrometry identifies compounds by the mass of the analyte molecule (“Gas Chromatography/Mass Spectrometry (GC/MS),” n.d.).



Figure 2 Schematic diagram of GC-MS

## Applications

1. **Criminal forensics**: GC-MS can analyse the particles from the human body in order to link a crime to a suspect as well as analysing fire debris.
2. **Environmental monitoring and clean-up**: GC-MS can track organic pollutants in the environment.
3. **Identification of unknown samples**: In chemical engineering, GC-MS is used for the analysis of unknown organic compound mixtures. One critical use is to determine the composition of bio-oils processed from raw biomass.
4. **Law enforcement**: Used for detection for illegal narcotics (Sparkman et al., 2011) as well as in forensic toxicology to find drugs and/or poisons in biological specimens of suspects, victims, or the deceased. In drug screening, GC-MS methods utilize liquid-liquid extraction as a part of sample preparation, in which target compounds are extracted from blood plasma.
5. **Food, beverage and perfume analysis**: Used for analysis of aromatic compounds in foods and beverages. It is also used to detect and measure contaminants from spoilage which may be harmful.
6. **Medicine**: GC-MS can determine compounds in urine even in minor concentration for earlier diagnosis and treatment of inborn errors of metabolism (IEM).

# Comparing GC and GC-MS

Gas chromatography is the technique to separate different molecule (containing different weight, size, binding affinity to the column) on the basis of their volatility. The inert gases used as mobile phase, assist molecules to move. Many times gas chromatography does not give appropriate separation results because of their close molecular weight, no speed difference, same/close affinities in column. To overcome this gas chromatography adjunct with mass spectrometry detector, which ionizes chemical species and sorts the ions based on their mass-to-charge ratio. Therefore, MS detector makes the identification process easier. In simpler terms, a mass spectrum measures the masses within a sample.

# References

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