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Review Article

A Review: Uses of Gas Chromatography-Mass Spectrometry (GC-MS) Technique for Analysis of Bioactive Natural Compounds of Some Plants

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ABSTRACT

Chromatography is the term used to describe a separation technique in which a mobile phase carrying a mixture is caused to move in contact with a selectively absorbent stationary phase. It also plays a fundamental role as an analytical technique for quality control and standardization of phyto therapeuticals. Gas Chromatography is used in the separation and analysis of multi component mixtures such as essential oils, hydrocarbons and solvents. Various temperature programs can be used to make the readings more meaningful; for example to differentiate between substances that behave similarly during the GC process. Intrinsically, with the use of the flame ionization detector and the electron capture detector (which have very high sensitivities) gas chromatography can quantitatively determine materials present at very low concentrations. Plants are a rich source of secondary metabolites with interesting biological activities. In general, these secondary metabolites are an important source with a variety of structural arrangements and properties. Gas chromatography - specifically gas-liquid chromatography - involves a sample being vapourised and injected onto the head of the chromatographic column. The sample is transported through the column by the flow of inert, gaseous mobile phase. The column itself contains a liquid stationary phase which is adsorbed onto the surface of an inert solid. The principle of gas chromatography is adsorption and partition. Within the family of chromatography- based methods gas chromatography (GC) is one of the most widely used techniques. GC-MS has become a highly recommended tool for monitoring and tracking organic pollutants in the environment. GC-MS is exclusively used for the analysis of esters, fatty acids, alcohols, aldehydes, terpenes etc. It is the key tool used in sports anti-doping laboratories to test athlete's urine samples for prohibited performanceenhancing drugs like anabolic steroids. Several GC-MS have left earth for the astro chemistry studies. As a unique and powerful technology the GC-MS provides a rare opportunity to perform the analysis of new compounds for characterization and identification of synthesized or derivatized compound.

Keyword: Chromatography, GC-MS, Bioactive compounds, Advantages, Applications.

INTRODUCTION

Gas chromatography has a very wide field of applications. But, its first and main area of use is in the separation and analysis of multi component mixtures such as essential oils, hydrocarbons and solvents[1-3]. Intrinsically, with the use of the flame ionization detector and the electron capture detector (which have very high sensitivities) gas chromatography can quantitatively determine materials present at very low concentrations. It follows, that the second most important application area is in pollution studies, forensic work and general trace analysis. Because of its simplicity, sensitivity, and effectiveness in separating components of mixtures, gas chromatography is one of the most important tools in chemistry. It is widely used for quantitative and qualitative analysis of mixtures, for the purification of compounds, and for the determination of such thermo chemical constants as heats of solution and vaporization, vapor pressure, and activity coefficients[4-9]. A knowledge of the chemical constituents of plants is desirable not only for the discovery of therapeutic agents, but also because such information may be of great value in disclosing new sources of economic phytocompounds for the synthesis of complex chemical substances and for discovering the actual significance of folkloric remedies. Higher plants as sources of bioactive compounds continue to play a dominant role in the maintenance of human health. Reports available on green plants represent a reservoir of effective chemotherapeutants, these are non-phytotoxic, more systemic and easily biodegradable[11-13]. Hence a thorough validation of the herbal drugs has emerged as a new branch of science emphasizing and prioritizing the standardization of the natural drugs and products because several of the phytochemicals have complementary and overlapping mechanism of action. In recent years GC-MS studies have been increasingly applied for the analysis of medicinal plants as this technique has proved to be a valuable method for the analysis of non-polar

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components and volatile essential oil, fatty acids, lipids and alkaloids[14-17].

Advantages and Applications of GC-MS

Forensic and criminal cases

GC-MS can analyze the particles from suspect to correlate his involvement in case. The analysis of fire debris using GC-MS can be established by American Society for Testing Materials (ASTM) standard for fire debris analysis[18-29]. It is also commonly used in forensic toxicology to find poisons, steroids in biological specimens of suspects, victims, or the deceased[30,37].

Environmental monitoring

The cost of GCMS equipment has decreased whereas the reliability has markedly increased. The determination of chloro-phenols in water and soil, polycyclic aromatic hydrocarbons (PAH), unleaded gasoline, dioxins, dibenzofurans, organo-chlorine pesticides, herbicides, phenols, halogenated pesticides, sulphur in air is very convenient to be screened by this technique. It can be used to screen the degradation products of lignin in bio-mass research, pesticides in spinach[38-47]. Analysis of decacyclene, ovalene and even C60 degradation analysis of carbamazepine and its metabolites in treated sewage water and steroid can be done without derivatization[48,49].

Food, beverage, flavor and fragrance analysis

Foods and beverages have several aromatic compounds existing naturally in native state or formed while processing. GC-MS is also used to detect and measure contaminants, spoilage and adulteration of food, oil, butter, ghee that could be harmful and should to be controlled and checked as regulated by governmental agencies. It is used in the analysis of piperine[50], spearmint oil, lavender oil, essential oil, fragrance reference standards, perfumes, chiral compounds in essential oils, fragrances, menthol, allergens, olive oil, lemon oil, peppermint oil, yiang oil, straw berry syrup, butter triglycerides, residual pesticides in food and wine[51].

Security and chemical warfare agent detection

Explosive detection systems have become a part of all United State airports, GC-MS. Is an essential part of chemical analysis unit. For enhancing capability in homeland security and public health preparedness, traditional GC-MS units with the transmission quadrupole mass spectrometers, as well as those with cylindrical ion trap (CIT-MS) and toroidal ion trap (T-ITMS) mass spectrometers have been modified for field portability and near real-time detection of chemical warfare agents (CWA) such as sarin, soman, and VX[13,14].

Astro chemistry and Geo chemical Research

The Huygens probe of the Cassini-Huygens mission landed one GC-MS on Saturn's largest moon, Titan. The material in the comet 67P/Churyumov-Gerasimenko will be analyzed by the Rosetta mission with a chiral GC-MS in 2014. Significantly enhanced molecular ions, major isomer and structurally significant mass spectral peaks, extended range of low volatility hydrocarbons that are amenable for analysis and unique isotope ratio information make GC-MS valuable for organic geochemical applications[52].

Medicine and Pharmaceutical Applications

Dozens of congenital metabolic diseases called as inborn error of metabolism are now detectable in newborn by screening tests using gas chromatography–mass spectrometry. GC-MS can determine compounds in urine even in minor concentration. These compounds are normally not present but appear in individuals suffering from metabolic disorders. This is easy, effective and efficient way to diagnose the problem like in case of genetic metabolic disorders by a urine test at birth[52]. In combination with isotopic labeling of metabolite, the GCMS is used for determining metabolic activity. Most applications are based on the use of 13C labeling and the measurement of 13C-12C ratios with an isotope ratio mass spectrometer (IRMS); an MS with a detector designed to measure a few select ions and return values as ratios. It is useful to detect oils in creams, ointments, lotion etc[16].

Biological and pesticides detections

GC-MS is exclusively used in bio-analysis of blood, urine for the presence of barbiturates, narcotics, alcohols, residual solvents, drugs like anesthetics, anticonvulsant, antihistamine, anti-epileptic drug, sedative hypnotics, narcotics and food items .This technique could be used for detecting adulterations, fatty acid profiling in microbes, presence of free steroids, blood pollutants, metabolites in serum, organo-chlorinated pesticides in river water, drinking water, soft drinks by head space, pesticides in sunflower oil etc.[53].

Petrochemical and hydrocarbons analysis

Significantly enhanced molecular ions that are always observed, isomer and structurally significant mass spectral peaks and extended range of low volatilite hydrocarbons that are amenable for analysis including waxes up to C74H150 makes the GC-MS a most valuable technique. Broad range of petrochemicals, fuels and hydrocarbon mixtures, including gasoline, kerosene, naphthenic acids, diesel fuel, various oil types, transformer oil, biodiesel, wax and broad range of geochemical samples can be analyzed by GC-MS[38,39].

Clinical toxicology

Enhanced molecular ions, extended range of compounds amenable for analysis, superior sensitivity for compounds and faster analysis are the main attractive features of the clinical toxicology. The toxin and venoms are identified by GC-MS. It is extensively used in clinical toxicology[17].

Industrial applications

GC-MS is used in industries for the analysis of aromatic solvents, inorganic gases, amino alcohol in water, impurities in styrene, glycol, diols, xylene, allergens in cosmetics etc. GC-MS is used for the characterization of formic acid in acetic acid for industrial use. In Industries acetic acid is important intermediate in coal chemical synthesis. It is used in the production of poly ethylene, cellulose acetate and poly vinyl as well as synthesic fiber and fabrics.

Energy and fuel applications

GC-MS is used for the analysis of aromatic solvents, sulphur, impurities in polypropylene, sulphur in menthane, natural gases, 1,3 butadiene, ethylene, gas oil, unleaded gasoline, polyethene, diesel.oil, unleaded

gasoline, polyethylene, diesel, modified biomass, grafted polymers etc.[24]. GC-MS has triggered a new arena of research and taken to new heights of impactful presentation and characterization of compounds by its wide range of applications[17,18].

Academic research

It is widely used in pure and applied sciences like Chemistry, Polymers, Nanotechnology and Biotechnology etc. It yields useful information that can be used in research publication internationally[53].

CONCLUSION

GC-MS is widely used in pharmaceutical industries for analytical research and development, quality control, quality assurance, production, pilot plants departments for active pharmaceutical ingredients (API), bulk drugs and formulations. It is used for process and method development, identification of impurities in API. It is an integral part of research associated with medicinal chemistry (synthesis and characterization of compounds), pharmaceutical analysis (stability testing, impurity profiling), pharmacognosy, pharmaceutical process control and pharmaceutical biotechnology.

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