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The Role of Chromatography in the Food Industry

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ABSTRACT

The widespread usage of gas chromatography for food analysis makes it a value for scientific research. The typical chemical and food analysis tasks performed by Quall Expand use mostly quantitative or qualitative analysis of food constituents, poisons, pesticides, and waste chemicals. As well as the changes in food taste and packaging, and odour composition, and work with various extraction procedures such as using water and steam distillation, solvents. This review provides a general introduction to gas chromatography research and mentions the main uses of gas chromatography in food science in addition to high-performance liquid chromatography (HPLC). Trends from past and forecasted implementation practices are noted, evaluated, and possible trends in the present and possible future behavior of food industries. They predict that in food applications, which do not include the already gas chromatography, the fastest-developing research methods in the next decade would be used known as gas chromatography. The main three methods for quick gas chromatography are low-pressure gas chromatography or TOFOT gas chromatography/time-of-MS, which is only briefly defined, and the features of a gas chromatography are evaluated.

Keywords- Food composition, Food Industry, Gas chromatography, Mass spectrometry (MS), High performance liquid chromatography.

I. INTRODUCTION

This is a well-known phrase: "You are what you consume, so you must be made up." Essentially, what we put in our bodies can be made up and sent out off converted to, after eating, and in our bodies must be changed to do with us. The vital thing to consider has the resources to survive. Resources will determine whether a community can grow or shrink. Death can't be abolished, but the value of food cannot be disputed.

Chemotherapy analysis provides information on the only method for determining which chemicals are present in food and how many of each kind there are. And then can we provide a piece of definitive information about the various nutrients or their influence on wellbeing can we learn something more. There have been a number of significant contributions to human growth by the identification and quantification of organic components in food, and chromatography has been crucial in particular for the isolation of complex organic molecules in food. With the commercialization of gas chromatography 50 years ago, the ability to assess food structure, the discovery of dietary requirements, and improved food safety has been realized. Gas chromatography has also been employed to facilitate nutritional research and the discovery of new foods in the modern era.

Furthermore, gas chromatography has proved to be the most reliable tool to quantify the compounds that are found in a diverse matrix of environmental and food samples with traces. noting that agriculture and industry play important roles in shaping human existence, we must use great care with agricultural and industrial chemicals to avoid hurting ourselves, the food supplies, and the environment on, which we rely, and also, the human ecosystem Any of the discoveries produced using gas chromatography in agriculture and food and science have been valuable in extending the life span of six billion people and adding nutrients and helping to provide food that is of higher quality and therefore nutritious food, bringing about a significant population growth. Comprehensive food analyses include a new investigation of the analytical chemistry of food components, their reaction with lipophilic substances, the sense of taste, and their odor. Gas chromatography recently touched on the first and then on these specific analyses, lipemic ones with amino acids, followed by those dealing with pest residues. The purpose of this article is to list the key functions of gas chromatography and discuss the current state of food analysis. We aim to have insight into the potential new and improved approaches that could be used to analyze food products in the future. We also decided to address only the developments in gas chromatography-MS. We believed that this technique would have the greatest effect if it can be used in regular food processing in the coming decade.

II. NEEDS FOR FOOD ANALYSIS

While various diet and health requirements define most needs for food analysis, pattern detection and palatability often serve as a consideration, and quality safety, taste and origin checking and contamination are all common reasons for looking through the method often affect food for commercial purposes, and mining for food items that can be used for both nutrition and secondary purposes. All of an

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analyst's requirements for food analysis begin with three basic questions:

- What does the food(s) in the current ecosystem consist of?
- Through contamination, accidental addition, application, or absorption by another food, or spoilage, these chemicals may occur in the food as a contaminant (how much or how many?
- And what extents are normal or human mechanisms involved in the modifications that exist in food?

All of these categories of answers are in reference to composition.

The methods presented in this article do not always reflect the appropriate or definitive applications in food analysis; however, it serves a valuable function by breaking down the application forms they are aimed at.

III. STRUCTURALIZED ARRANGEMENT

More than half of the food's components are liquids, lipids, and carbohydrates; the others are fats, carbohydrates, vitamins, and minerals. Water is a major component of food; nevertheless, it is often removed during compositional examination, and thus must be extracted before being determined. For most foodstuffs, ash percentage as a secondary is around 20% or less. This provides a compositional triangulation of the other two significant remaining components, seen in Figure 1 this assumes new, uncompressed or untried mineral content, as a calculation of the three: lipids, proteins, and carbohydrates. This is a handy food categorization tool, allowing the food scientist to divide the food triangle into nine parts depending on the chemicals present in the food.

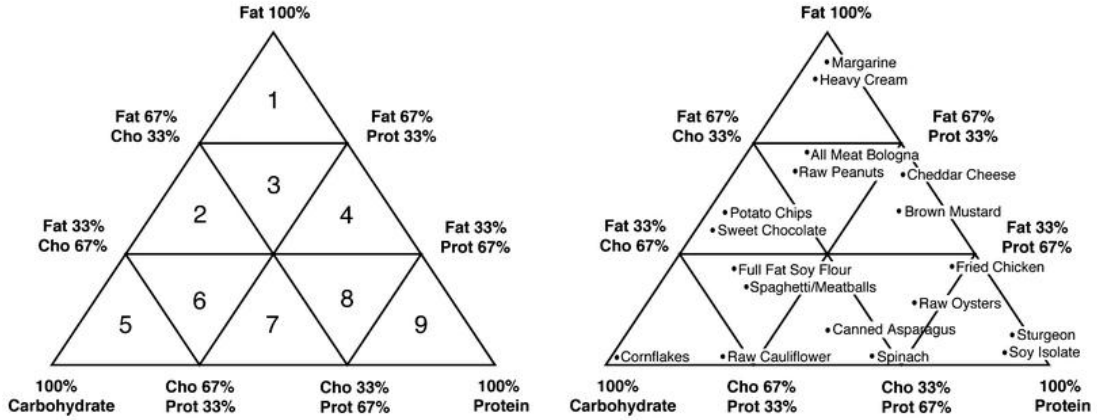

Figure 1: The food-composition triangle is classified into nine categories, each with samples of various foods.

The majority of countries mandate all packaged goods to be measured and provide their constituent elements to the customer in the form of either a formula or in a specified food ratio on the label. Many food composition tests are done every day because the food processor still has an interest in being mindful of the product's composition. Although gas chromatography is seldom included in the more extensive quantitative procedures, but rather used for identifying fatty acids, sterols, scents, esters, and fragrances, it is the principal approach to multispecies research in food, other usage applications. The preferred analytical approach for studying every volatile food component is gas chromatography, subtraction, and underwater reactants.

For that reason, several agrochemicals are applied to support the volume and quality of food required for this scenario the nine food groups are made up of many various types of carbohydrates, proteins, fats, and vitamins and other trace elements.

Agrochemicals, which are usually shows up in the food, are poisons that may be used at any time of the year, and hence they are agrochemicals (herbicides, insecticides, acaroids, and fungicides). This also contains the generic term for medicines known as animal derived drugs, which might be remnants of medications that may be used in animal products such as animal by derived food ingredients (e.g. antibiotics, growth promo ants, anthelmintic). Excessive amounts of different chemical toxins can be found in food, such as hydrocarbons, polycyclic aromatic hydrocarbons, and organometallic compounds—their introduction by the atmosphere or through the air, as well as a conduit. Food can be tainted by multiple microorganisms, such as microbes or moulds, or it can become toxic due to contaminants naturally occurring in the food or as a result of spoilage. Any materials used in the packaging can seep into foods and beverages during the production process.

Additionally, food additives, such as organic preservatives and artificial antioxidants, can be applied to the food before or the harvesting and before long- or refrigerated storage to maintain its freshness and prolong its shelf life. Other food additives (such as dyes, emulsifiers, sweeteners, or synthetic flavor ants) can be used to give the food a certain appearance or to improve

its taste or texture. More chemicals and toxins than anybody might ever imagine and are governed by various entities in the world. There are undoubtedly far more than a million studies of agricultural toxins and additives completed per year by the food sector, academia, and private labs, including governmental and contractual. Often known as gas chromatography/used as the general cheminformat, this machine is used to measure several chemical pollutants and additives. Remodeling pojects, elixirs influences that can bring about unwanted changes in food the food's processes may include various industrial ones others that can introduce substances that may trigger alterations and agricultural conditions or technological influences. The types of compounds defined as being transformational products are polycyclic aromatic hydrocarbons, heterocyclic amines, nitrosoamides, Chloropols, histamine carbonyl derivatives, and spoilage microorganisms. Such as metarampyldones and Coryndesignals induce rancidity; the final additional list includes polycyclic molecules, Chloropols, histamine nitroestols, nitrosochromes, and nitrosamines, which are described as transformation contaminants. Certain hazardous and undesirable chemicals are often to be properly labelled in order to be covered, though the manufacturers do not want to risk an adulterated, spoiled, or low-quality product. Due to the prevalence of business and volume of food safety studies, the majority of food analysis takes place in commercial or independent testing labs.

IV. CHORMATOGRAPHIC STUDY OF FOODS

Quite often, gas chromatography is used for analysis of non-polar and semi-volatile, and semipolatile chemical compounds. Although gas chromatography is effective for separating components such as sterols, triglycerides, fatty acids, and aldeoxy derivatives in food, there are numerous applications for which it is no need for chemical derivatization. Such as the study of some pollutants, medicines, pesticides, and industrial toxins, the low chain- To use different methods, such as HPLC to separate all chemicals regardless of volatility or polarity, is a viable method of separation approach. The chromatography column holds much promise as a potential, but has been instead employed mainly for polar, and labile, and particularly non-volatile analysis because of the many advantages to it. Glycerides and alkyl derivatives, lactic acid, and purine analogs are widely found in animal tissue and derivatization of organic substances such as amino acids, polycarboxylic acids, supplements, and other veterinary medicines, as well as chemical derivatization, allows them to utilize gas chromatography methods. Non-v-volatile compounds are a pure (inorganic salts are excepted) due to their non-ability to pyrolysis, such as polysaccharides, nucleic acids, and larger-molecular weight organic molecules including proteins and polymers cannot be produced by any kind of decay, except by the decomposition.

However, it is widely acknowledged that gas chromatography and HPLC are useful tools, but had also led some researchers to use the use of HPLC where the latter technique's ability to expand to have a clear benefit. In recent years, the larger instrument producers have devoted more of their time to LC-gas chromatography analysis, allowing smaller firms to go on with advanced applications including injections, separations, and identification, on a challenge for the next in industrial use. To evaluate and equate gas chromatography and high-performance liquid chromatography (HPLC) techniques in food applications. It is easier to look them up in a literature-free database or estimate and compare them with literature. though intended for the biochemical researchers, the National Institutes of Health has a comprehensive database containing several major analytical and applied publications, but this information is mostly for those who do laboratory research with the NIH Internet presents a succinct database that gives a laboratory researcher the entire references to major analytical and applied research publications but in a full and data but it's important to see patterns to give the reader an idea of how much things have changed.

In the chart above, the image, we see how the number of publications correlates to the key food use, together with the procedure used for that food, such as chromatography, throughout the years. The search words used to narrow the results were gas chromatography or HPLC + food quality or food and beverage quality and high-performance liquid chromatography. Thus failed to discover those papers, which only mentioned high pressure instead of high efficiency or gasoline chromatography. As you must expand Figure 2 to understand the definition, the caption contains the search words that would be needed to get you there.

The most commonly used Google searchable (according to the search parameters) terms for food analysis are: 1) lipids; 2) pesticides; 3) and 4) drug analysis; and 4) food and drug analysis.

On the basis of HPLC, the most common use patterns are: medication use, amino acid and protein analysis, carbohydrate and lipid testing, and exploration, and final stage carbohydrates and polymers.

Figure 2 in the food composition is accurate to the amount of articles on additives and contaminants. As opposed to chromatography, the food-position papers account for the majority of the papers in the market. Research into the transformations goods that make up an application (i.e. products that convert or express a need) has lower priority than general demand research.

The two methods shown in Figure 2 reveal that, during the decade covered in the food and agricultural sciences, in the course of commercialization of the original gas chromatography technique. The increase in

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the frequency of use of HPLC as a Food/agricultural (within the search parameters). For standard gas chromatography uses, such as separating lipids, HPLC are still used just a fraction of the time, and has fallen behind in terms of publication.

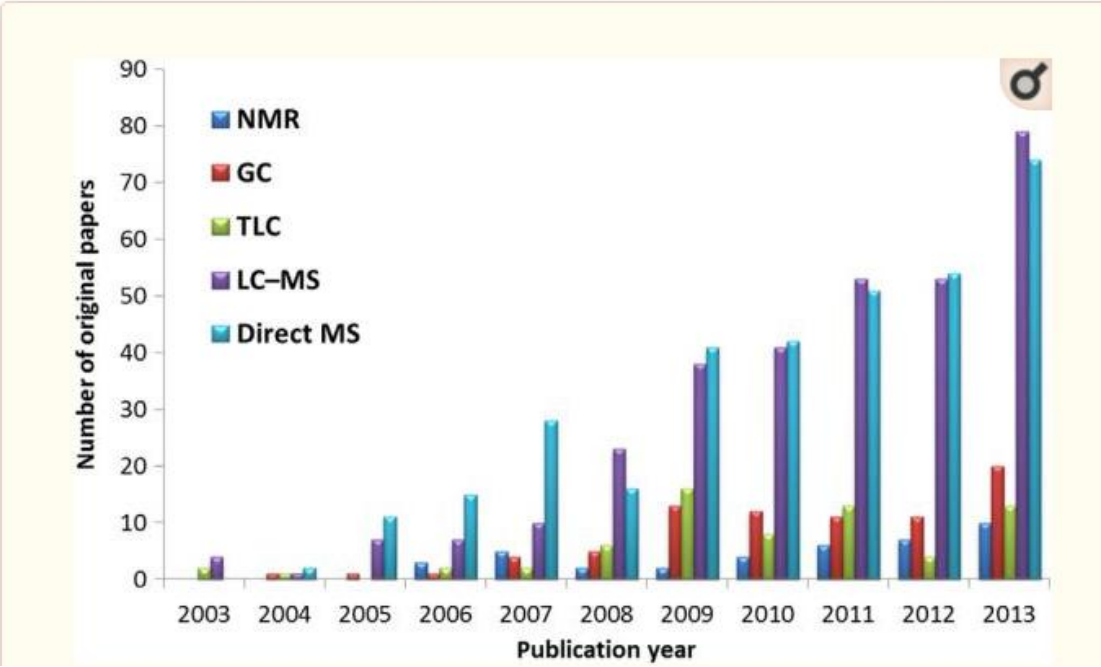

Figure 2: Comparison of gas chromatography and HPLC in major food applications over three time periods.

V. TRENDS IN ANALYSIS

Food applications in the concepts and research include making an educated guess, however, since no matter what happens in the future, food can allow the food science to make educated guesses about what the future will hold. The main priorities in routine applications of analytical chemistry have often been to meet these requirements: to provide greater precision, lower detection limits, and higher selectivity, as well as improved and more rapid methods on smaller and more compact equipment, both of which need less time and money. An general movement towards greater number of smaller detection limits coupled with improved the techniques has given way to real patterns that enable more material to be sampled at greater rates, however the methods themselves are less easy to use (and consequently more expensive). The correct approach this poses a substantial threat to successful technologies and only applies successful techniques (higher detection limits with selectivity) before anything better presents itself? What is the net effect of this new approach whether it is a significant or limited in number of customers, quick and/cheap, but provides worse results, or not particularly good results, becomes widespread?

This experiment is based on an in part on solid-phase microextraction, which examines different cases that seek to address the questions mentioned above (SPME). Compared to gas chromatography, SPME is significantly enhances the capability of both gas chromatography and LC-MS, facilitating the extraction and detection of volatiles in food samples. Since its launch, SPME has been subject to more than 1,000 publications, however because of the difficulties with quantization, overall findings are compromised, SPME's overall sensitivity is greater than its precision; because of this, in addition, it also the overall pace is diminished, however with a slight adjustments, the effect on accuracy can be restored. However, as seen in Figure 2, a few expansions in the SPME sector would be qualitative and restricted. It would be very interesting to see how SPME is faring in the coming decade.

He projected what he thought would happen to food research patterns in the 1980s from the earlier part of the decade. Predicting that the continued dominance of the packings of capillary columns is correctable was the only way to go in the field of some theoretical analyses of the analytical trends at the moment. Later, as new technologies like machines were used to run complex instruments and long runs, the throughput will improve significantly, though, as a second assumption has proven to be correct: further work will be done every second, reducing time required for analysis and thereby running experiments. about all scientists concur that the electronic revolution has been a great benefit to their work and some of their experimental techniques, or equipment are not practical without them but Tanner also felt that it would be less necessary to look for foods down in the 1980s so the trend to lower limits would be

continuing. Traceability of the emissions already measured was of primary importance, but further traceability and compatibility were essential. One may make a similar case in food composition-m applications: food composition does not involve minimum levels of quantification (LOQ).

On the general, demand has remained flat, as long as lower LOQ injection isn't required by law. This is very beneficial because it allows the use of diluted samples, which is often welcome, particularly in gas chromatography (to reduce coinjection of non-volatiles). If you are looking for lower detection limits, it is essential to employ a lower-number of components and to avoid clean-up and solvent evaporation. Considered a loss of technology with smaller, less multi-step, length, and chemical processes to be desirable because of the increase of LCR instrumentation, the last 20 years has also seen the emergence of more simplified, streamlined, direct approaches that have a handful of minuscule equipment and can use.

But lower-with no influence in discriminating small interferences: Since matrix interferences are the limiting factor, there is no discernible effect on detection limits. and is often stronger because of the lower detection limits are essential when it comes to the function of greater selectivity (preparation techniques, as well as analytic separations and detection methods). Such a greater progress has been made in the detection limits on particular gas chromatography compounds, such as selective gas chromatography, that expansion cannot be prevented. In the developed nations and part of its overall potential to provide confirmation, gas chromatography has emerged as a key instrument for certain food analysis laboratories because of its capacity to measure multiple tests at a low concentration.

VI. THE VIEW IN THE '2003

In 2003, the more sophisticated and advanced technologies could have been seen as sure bets when seen from the perspective of where one's abilities to accurately forecast the future The atomic emission detector was invented in the year 2003 with a great deal of real enthusiasm and a few commercial claims to back it up. There are benefits when using a highly sensitive detector, like the mass spectrometer in the mass specular, which allows a researcher to expand the target compounds and enhance the ability to spot many different elements at once. It was not a fantasy; the detection limits were low enough for contrast, but they were less too much greater than the other ones that the usage of this type of sensor was also restricted. AED will serve as a powerful research tool for helping to discover the analyses, but it also as a great research tool for systemic elucidation and identifying the analyses. Although there was no doubt the machine was beneficial for its own intended purposes, AED was cost prohibitive in much of use applications outside of the food industry. The last industrial producer of the AED (Automated External Defibrillator) decided to discontinue their production in 2013.

Food-analysis was pushed to new limits throughout the 2003s and 2013s, with its useful uses having mostly either significantly increased or reduced. In part, broad terms, a partial, supercritical fluid, supercritical fluid chromatography, dispersive extraction, and dialysis may be lumped together in the list of procedures that increase the concentration of those components. Specialized implementations have still remained with these approaches, but don't apply these procedures broadly because of negative connotations that were created by using empirical methods or language. Estimate the prevalence of current and predicted developments competition from the large, established players would go head-to-head with those currently dominating the competition in the race to produce advanced analyses. While gas chromatography, HPLC, solid phase extraction, and liquid-liquid extraction are among the majority of the modern analytical methods, conventional detectors are most often found to be the best. Because of the prominence of previous analytical instruments such as thin-layer chromatography, Soxhlet extraction, wet chemical, and the problem of chromatography in non-polar media, previous approaches have been relegated to tools that are of no use in the polar solutions. Our top-of-the-the-the-the-line features and best-of-in-the-the-class technology are proven parameters; any new approach would have to be equivalent or surpass them to them in their qualities for a fair price. In order to maintain their lofty positions, are there emerging innovations available that can step in and perhaps overtake these leaders?

The main advances in HPLC and gas chromatography, along with programmable temperature vaporisation (PTV), pulsed flame detection (PLDPD), and pressurised liquid extraction (XPD) in instrumental devices have all of strong applicability to food analysis (ASE). One or more of these methods have been on the market for at least six years, and may continue to be valuable for several years to the following.

There are now several gas chromatography instruments on the market that could be used to resolve possible food borne pathogenic microorganisms like large-volume injection (LCI) and resistance pipettes and chromatography using Resistive Heating and Capillary Electrophoresis. Both of Components Tobacco's methods are also in the process of being confirmed as being used and their potential use remains unclear. Many applications of MS in which a quantitative as well as well as qualitative feature expansion are needed (dependence on good glucose control, of relative abundance of glaucom dozwsis on numerous experiments) could lead to its eventual domination in the field. MS detectors are likely to stay in demand because they're better equipped to handle, or identify, those chemical compositions; thus, supplementary selectivity

and/sensitivity detectors like PFPD and DS would still continue to be required, since they are affordably available. But the future of gas chromatography detection and applications is tied with MS. Although MS will begin to wonder how big the capital investment in the laboratory will make to achieve the advantages of MS, the crucial question to ask is: How much more investment does the lab need to do them need to pay?

VII. FASTER GAS CHROMATOGRAPHY/MS

Increasing the separation time has always been an objective for gas chromatography has always been a priority of advancement In a lot of cases, the time it takes to separate the generative core gets longer. Increase carrier flow; decrease film thickness; increase carrier viscosity; reduce diameter having a faster throughput reduces the amount of sample space available, increasing the detection limits, as well as lowering the separation performance. The analyst is able to compromise pace in exchange for how many of the other considerations He discovered that the times required for everyday separations have not changed much in decades, according to what he found on the internet. Perhaps, if more instruments are available with higher throughputs and lower inlet-limit settings, there will be greater usage of faster oven programme speeds, though faster electronics will still remains.

In practise, we want to run analyses as quickly as possible. Still, the gas chromatography requirements should also be able to yield useful results, at a selectivity threshold. Selectivity with detectors may help improve the selection of the matrix but will be limited by the needs of the analyte, resulting in the need to separate it first. The sensitivity of PCB/dioxin examination typically increases through PCB+d speciation, which may be an anomaly in nature, since certain congeners of PCBs have a lower mass than the amount of their concentrations. When working with a reduced gas chromatography strategy, gas chromatography eliminates the need for isolation, leading to quicker analyses of the whole list of matrices and analytes.

The majority of chromatographers seem to believe that each analyte should be resolved and each phase of the separation. On the one hand, selective ion monitoring (SIM) and tandem allow for greater chromatographic purity on the use of sequential fragments, whereas on the other, they increase the length of certain phases.

There are at least three strategies for gaining quick confirmation; gas chromatography/MS: utilization and micro-beam columns of time-of-flight (TOF). The use of faster gas chromatography column time is the only factor being evaluated; it is not necessary to discuss the possibility of using other slower gas chromatography timings. Not much investigation has been done on these quick modern methods in general since they have not been in widespread use for some time; nevertheless, some of them have shown to be very desirable in specific situations. To a degree, all three techniques have been investigated similarly, with regards to use with which they've been examined and used for the purposes of applying pesticides and their residual treatments. The contrasts in Figs. 3–5 are on this one application, such that each solution can be evaluated in a similar context. This user guide can be read in conjunction with various other food application literature to expand on the ideas and techniques presented.

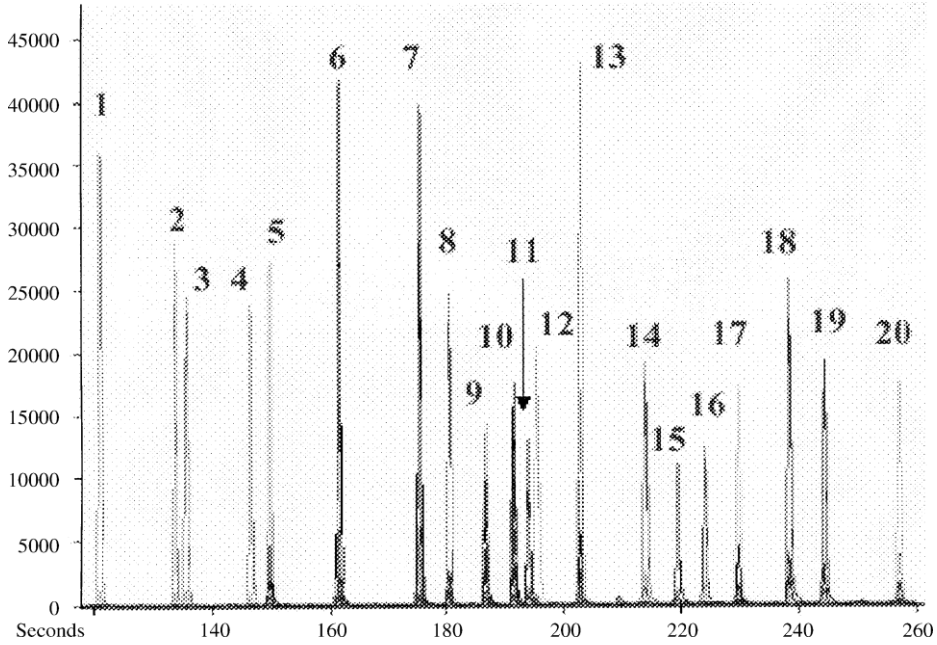

Figure 3. Fast-gas chromatography analysis of pesticides.

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VIII. GAS CHROMATOGRAPHY/TOF-MS

One of the benefits of the micro-bore gas chromatography/TOF MS system versus the other methods is that the separation performance may not have to be impaired for speed of study. Quadrupole gas chromatography-MS instruments will search at a high enough pace to satisfy the demands of fast gas chromatography MS. TOF-MS is the only MS method that can simultaneously reach through many spectral bands in complete scan mode. A figure illustrating the use of a rapid gas chromatography procedure for analysing pesticides in a solution is shown in Figure 3. On the other hand, injecting the most complicated extracts severely damages microbore columns and their output decays rapidly due to the reduction in sample ability in comparison to column diameter, which means they are barely useful in non-quantitative analyses, so narrow columns should only be used in laboratory settings where small amounts of samples are used.

Spectral Expanded Mass Range/Spectral Mass Range also has wide coverage and outstanding quality. Gas chromatography or TOF columns don't have to attain the brief review times need not be of micro-bore but long. Using the narrow columns for applications which need to heat to rapidly, using Expand or rapid, ballistic or resistive heating in gas chromatography/TOF-MS, and doing detailed 2D/low pressure in gas chromatography/TOFMS may be a future option.

IX. LP-GAS CHROMATOGRAPHY

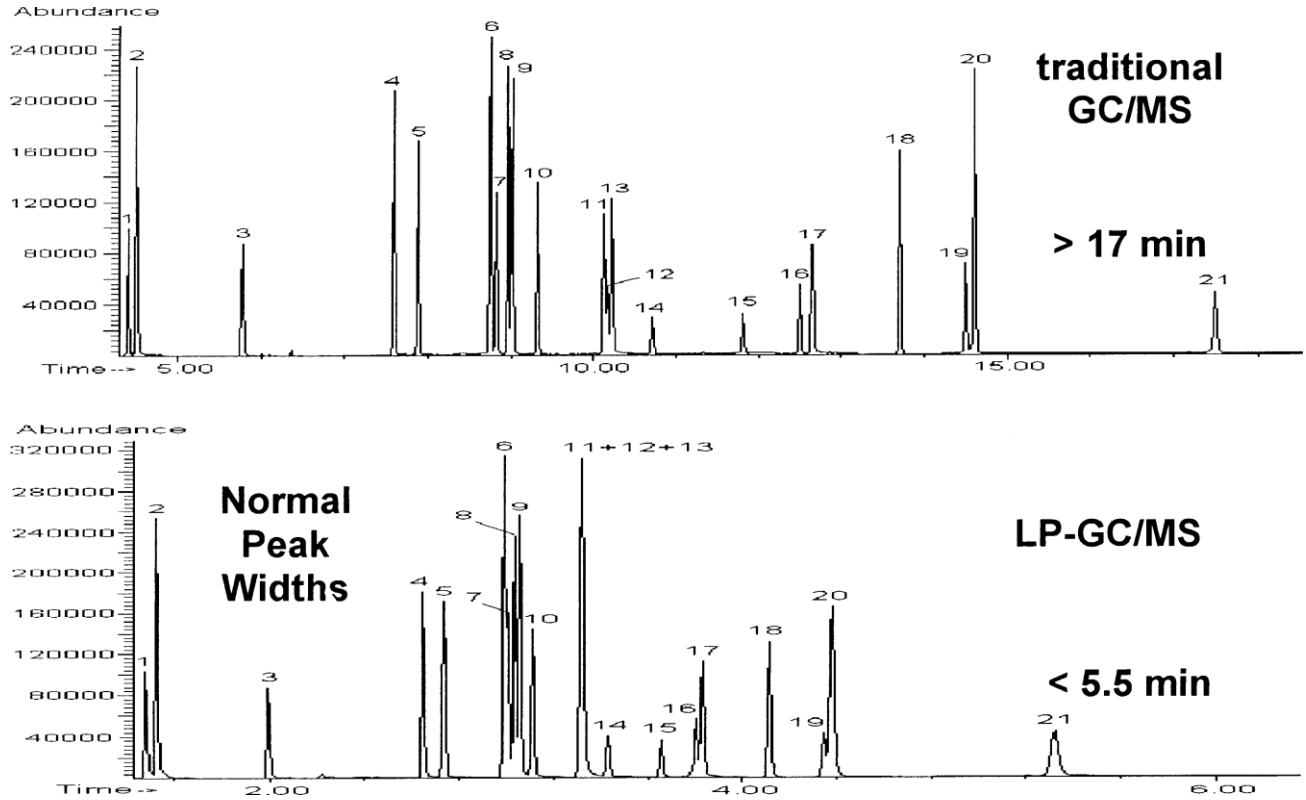

Figure 4: Chromatogram of pesticides in toluene solution in conventional gas chromatography-MS and LP-gas chromatography/MS

Next, Rapid-MS, or LP-MS, is a very fascinating methodology where a small (10 m Mega D) column (i.e. 53 mm ID) is used instead of a normal length (50 m Mega D) as the analytical column. the large bore of the device makes it possible for the tubing to extend further into the column and obtain higher flow and flow separation than other models There is a positive inlet limitation at the injection port with a nominal diameter of 0.1–0.25 mm for standard methods being applied to have a pressure expandability range of 0.1 to 0.15 kPa. Current methods and the: Current instrumentation does not need to be altered because of the Expand Advantage 1) normal liquid chromatography is capable of achieving fast separations; 2) sample capacities and injection volumes are all increased due to the mega-bore columns; 3) normal peak shape LC separation gives similar peak heights and LOQ to MGAs chromatography separation, and 4) injection method LOQ may be reduced because polar analytes display normal shape peaks.

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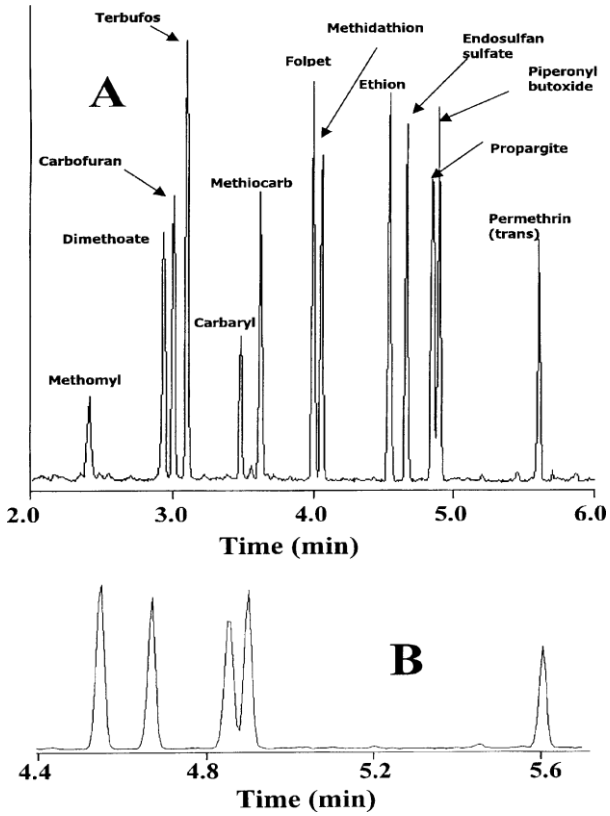

Figure 5: Fast-gas chromatography/SMB-MS analysis of the indicated 13 pesticides in methanol (3–7 ng injected).

Plots demonstrate how a three-fold increase in the number of the research compounds was obtained by applying liquid-gas chromatography and tandem mass spectrometry compared to conventional gas chromatography and mass spectrometry. Big injections of liquid chromatography/liquid chromatography with a were made possible due to the ability to improve focusing of the mobile phase in the latter and column power, therefore, greater sensitivity was achieved. However, greater interconnectivity was achieved with multi baseline measurements coupled with low-LC/relatively low separation performance (compared to multi baseline analyses coupled with a conventional methods), which is particularly prevalent with multiple injections and re-gasification methods.

X. GAS CHROMATOGRAPHY/SMB-MS

Due to current instrumentation and architecture, the gas chromatography-MS expansion rate has reached a realistic limit of 2 mL per minute. Gas chromatography/SMB- MS is a great since it eliminates this flow restriction at the MB/sMB place. Although only one gas chromatography has been implemented at this point, it is not commercially usable; it's useful only in a single-prototype context at this moment.

Any of the benefits of gas chromatography include: Gas chromatography at lower temperatures eliminates HPLC tailing selectivity. As an illustration, Figure 5 illustrates the use of various gas chromatography approaches for pesticide isolation in Figure 1. 3.

XI. CONCLUSIONS

Commercial high-half-century grade gas chromatography's history has been a half-century long, and that history is only getting started. This technology has so far shown that huge amounts of new product possibilities can be realized with it or more exploits to be gained. The challenge facing current software programmes is making high-quality garbage collection and understanding available to all their users, as well as a never-ending exploration of the chemical effects on human and environmental health is never-ending.

Generally, when gas chromatography should be used for a split, it is preferable to use HPLC. None of today's other methodologies will equal the separation effectiveness, the depth of instrumentation, excellent instrument accuracy, low cost, simple implementation, and diverse capabilities of M O approaches.

Due to the superior detestability of modern gas chromatography approaches. Additionally, as newer gas chromatography/MS methods continue, the usage of gas chromatography will rise. If the selectivity of the MS improves, baseline separations can be achieved with less complex detectors, faster resolutions of lower chromatography are also are useful. Three new gas chromatography techniques can likely prove useful for this objective: direct off-glass micro sac FID and gas chromatography or mass spectrometry.

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