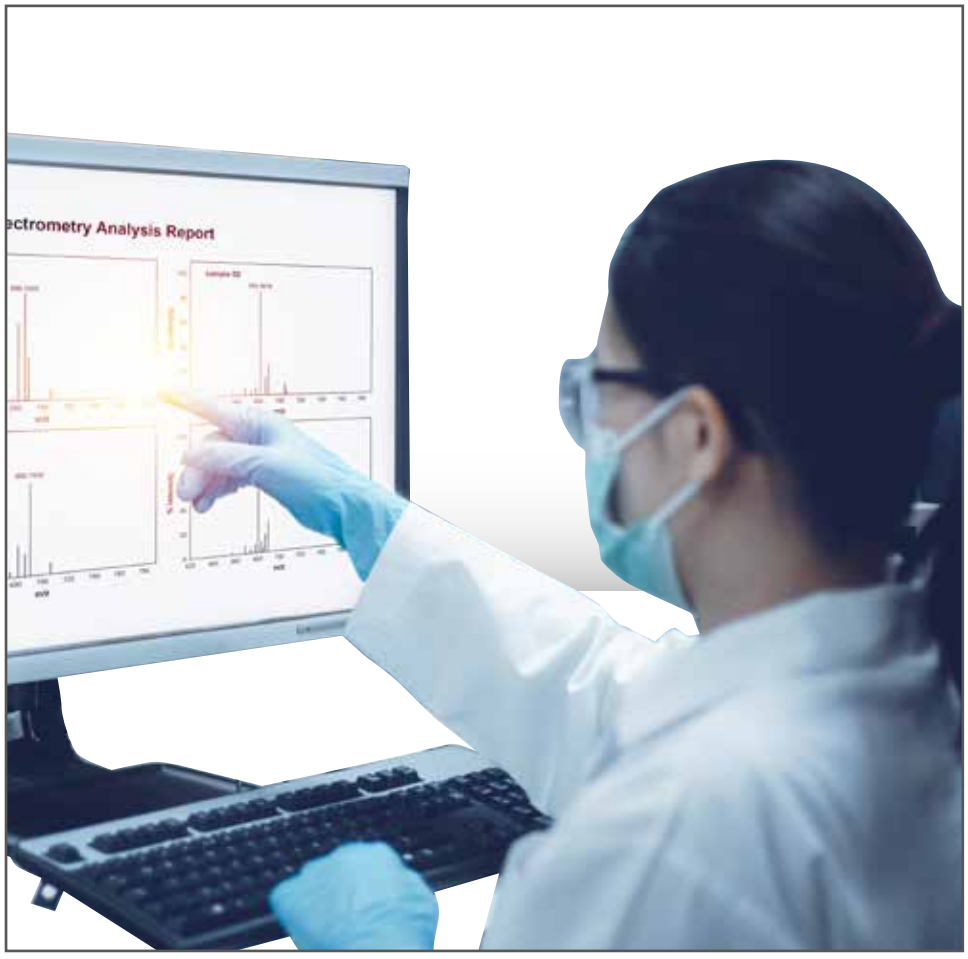
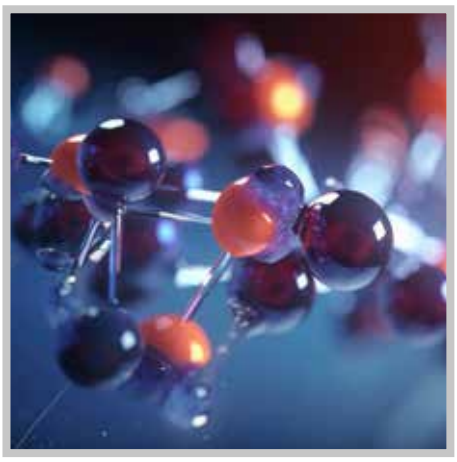




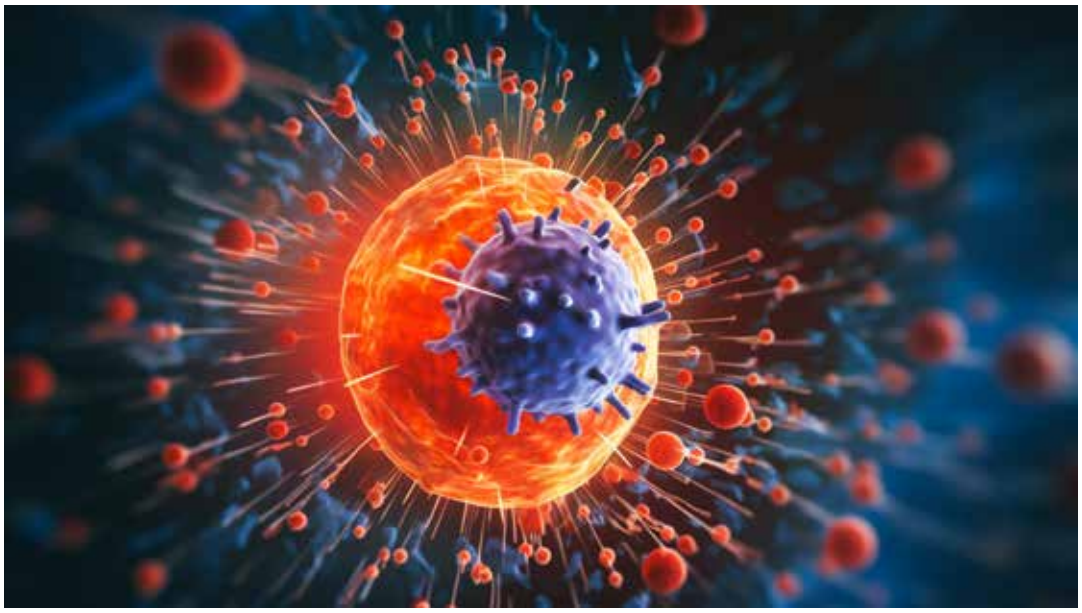
Mass Spectrometry

Vacuum solution for mass spectrometry

PFEIFFER VACUUM

Mass Spectrometry

Overview



Introduction

Mass spectrometry is a significant analytical method used for the identification and characterization of molecules. It enables the determination of the mass and structure of compounds and provides detailed information about their chemical and physical properties. In recent decades, mass spectrometry has gained importance in scientific research as well as in various industrial sectors.

History

Mass spectrometry has its origins in the early 20th century when scientists such as J.J. Thomson and Francis W. Aston conducted pioneering work in this field. Thomson developed the first mass spectrometer, while Aston carried out significant research on precise measurement of atomic weights, for which he was awarded the Nobel Prize in 1922. Over time, the techniques and instruments of mass spectrometry have been further developed, including the introduction of gas chromatography-mass spectrometry (GC-MS) in the 1950s and 1960s. Further advancements followed with the introduction of liquid chromatography-mass spectrometry (LC-MS) and matrix-assisted laser desorption/ ionization mass spectrometry (MALDI-MS). Today, mass spectrometry is an established and versatile analytical technique that continues to be improved and makes a significant contribution to advancements in science, medicine, and environmental protection.

Significance in science

Mass spectrometry is an indispensable tool in scientific research and plays a significant role in various disciplines. It enables the precise analysis of molecules at the molecular level and provides important information about their mass, structure, and composition.

In chemistry, mass spectrometry plays a crucial role in the structural elucidation of organic and inorganic compounds. It allows for the identification of functional groups and the investigation of reaction mechanisms, contributing to the development of new catalysts and the optimization of synthesis routes.

Mass spectrometry has established itself as an indispensable analytical technique and makes a significant contribution to scientific research, the development of new therapies, and the optimization of materials in a variety of disciplines.

In addition to standard pumps, we offer customized solutions and we also do the vacuum design and calculation for you.

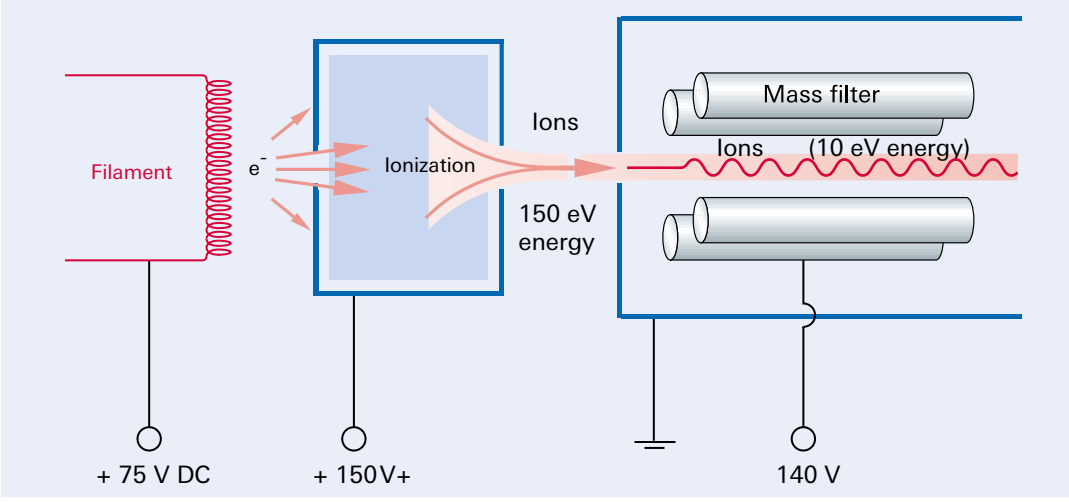
Mass Spectrometry

Fundamentals

Function

The basic principle of mass spectrometry is based on the separation and detection of ions in a mass spectrometer. First, the sample is converted into the gas or liquid state and transformed into ions. This can be achieved through various ionization techniques such as electrospray ionization (ESI), matrix-assisted laser desorption/ionization (MALDI), or chemical ionization. Ionization leads to the formation of charged molecules, which then enter the mass spectrometer. In the mass spectrometer, the ions are separated based on their mass and charge. This is typically done in a mass analyzer, which can include different types. One commonly used mass analyzer is the time-of-flight mass spectrometer (TOF), where ions are separated based on their flight time through an electric field. There are also other types of mass analyzers such as quadrupole, ion cyclotron resonance (ICR), Iontrap, and magnetic sectors, each utilizing different separation principles.

After separation, the ions are detected, and their intensities are measured. This is usually done by a detector such as a secondary electron multiplier (SEM), a microchannel plate array (MCP), a Faraday cup, or a semiconductor detector. The measured data is then represented as a mass spectrum, which depicts the relative intensities of the ions as a function of their mass.



Basic principle of mass spectrometry

The mass spectrum contains valuable information about the analyzed sample. Different types of peaks corresponding to different molecular ions can be observed. The position of the peaks in the spectrum provides information about the mass of the ions, while the intensity of the peaks provides information about the relative abundance of the ions. Using this information, molecules can be identified, their composition determined, and quantitative analyses performed.

Overall, mass spectrometry is a versatile and powerful analytical technique that is of great significance in many scientific fields It enables the examination of molecules at the molecular level and provides crucial information for research, development, and quality assurance in various industries. Through continuous advancement and innovation, mass spectrometry remains an indispensable tool in modern analytics.

Mass Spectrometry

Techniques

Mass spectrometry is a versatile analytical technique used in various fields of science and analytics. There are several specific techniques based on different principles, each with their own application.

RGA – Residual gas analysis:
RGA is a mass spectrometry technique used for the investigation of residual gases in a vacuum. It enables the identification and quantification of the chemical components of a gas, as well as the determination of pressure, temperature, and other parameters.

LC-MS – Liquid chromatography-mass spectrometry
LC-MS combines liquid chromatography (LC) with mass spectrometry (MS). This technique enables the separation and identification of compounds in a liquid sample. It is commonly used in pharmaceutical analysis, environmental analysis, and food analysis.

ICP-MS – Inductively coupled plasma-mass spectrometry
ICP-MS is a technique that combines mass spectrometry with an inductively coupled plasma (ICP). It is used to quantify trace elements and metals in various samples, such as in environmental monitoring, geology, forensics, and the food industry.

GC-MS – Gas chromatography-mass spectrometry
GC-MS combines gas chromatography (GC) with mass spectrometry (MS). This technique enables the identification of volatile organic compounds in a gaseous sample. It is commonly used in the analysis of organic compounds, such as in environmental analysis, drug analysis, and forensics.

MALDI-MS – Matrix-assisted laser desorption/ionization mass spectrometry

MALDI-MS is a technique used for the analysis of large biomolecules such as proteins and peptides. It enables the ionization of the sample by a laser mixed with a matrix substance. This technique is used in proteomics, drug development, and clinical diagnostics. MALDI MS is mostly combined with TOF-MS (Time-of-Flight Mass Spectrometry).

TOF-MS – Time-of-flight mass spectrometry

TOF-MS is a technique where the masses of ions are measured based on their flight time in a mass spectrometer. It is characterized by high mass resolution and high sensitivity and is used in many areas such as proteomics, metabolomics, and environmental analysis.

Each of these mass spectrometry techniques has its specific applications and advantages. The choice of the appropriate technique depends on the nature of the sample, analytical requirements, and compounds to be investigated. Experts select the most suitable technique based on the specific requirements of their research or analysis.

HiPace 80 Neo	Customized SplitFlow	MVP 010	HiScroll 6
Turbopump	Turbopump	Diaphragm pump	Scroll pump
			
■ Patented laser balancing technology ■ High performance lubricant ■ Compact size ■ Minimal vibrations ■ Long service life and low operating costs ■ Complete series from 10 m^3/h to 2.300 m^3/h	■ Compact desing makes for mimimum footprint ■ High pumping speed and maximum compression for all gases ■ Customized pumps from 10 m^3/h to 700 m^3/h	■ Completly dry and oil-free vacuum ■ Long diaphragm service life ■ Low noise and vibrations levels ■ Excellent operational reliability ■ Maintenance-friendly	■ Oil-free vacuum pump ■ High comfort and low vibration ■ Sustainable and energy efficient ■ Extremely quiet: <47 dB[A] ■ Very good final pressure: $<1 \cdot 10^{-2}$ hPa

Mass Spectrometry

Residual gas analysis (RGA)

Introduction

Users in many applications are faced with the question of how clean the vacuum apparatus actually is. It is also very important for process monitoring to know the composition of the residual gas. Vacuum pressure measurement gives us information about how many contaminations still remain in the chamber but not about what contaminations they are. Quadrupole mass spectrometers (QMS) can be used to perform a residual gas analysis that answers this question. Once it is known which species are left in the chamber, additional purification steps can be taken or the application itself can be started.

How does it work?

Like all mass spectrometric instruments, quadrupole mass spectrometers (QMS), are made up of three parts: an ion source, an analyzer and a detector. All components in a quadrupole mass spectrometer require high vacuum to function. The neutral gas particles are ionized in the ion source. A common ionization method is electron impact ionization.

Ions generated in this way pass through extraction lenses before entering the analyzer with its electric quadrupole field. Using voltage comprising both an high frequency alterning voltage and direct voltage component, an electric field is generated within 4 high-precision metal rods. This quadrupole field is where ion discrimination takes place on the basis of their mass-to-charge ratio.

Accordingly, only ions of one specific mass-to-charge ratio are able to pass through the rod system and reach the detector. All other ions are located on unstable trajectories and are discriminated in the apparatus. The detector in its simplest form is an electrically conductive hollow body known as a Faraday cup. The ions are neutralized by the release of charges and the resulting current is detected.

A Faraday cup is sufficient in terms of signal strength to perform a residual gas analysis in high vacuum. Where very small ion currents are present, as in the ultra-high vacuum range, or where very fast measurement is required, a secondary electron multiplier (SEM) is normally used. Utilizing a mass spectrometric setup such as this, the user can detect which substances are still present in the vacuum system.

Requirements

Pressures of $<10^{-4}$ hPa are required for ions to pass through the analyzer with its electrical quadrupole. These pressures are necessary to ensure the mean free path is long enough for the ions to reach the detector on their trajectory without colliding on the way. To achieve the necessary vacuum pressure, it is ideal to use a combination of a backing pump and a turbopump, either as a modular or a ready-to-use pumping station.

Gas inlet systems developed for different pressure ranges enable the user to adjust the pressure precisely to the QMS. Because the QMS can be damaged if used at pressures that are too high for it, it is recommended that a total pressure measurement is integrated.

Product portfolio

The wide range of potential uses for the quadrupole mass spectrometer goes hand in hand with a large variety of application options It must be understood that not only the gases to be analyzed are important but also the inlet pressures. Residual gas analysis must therefore be considered as a combination of the mass spectrometer, the inlet and the vacuum system.

HiPace 80 Neo	Customized SplitFlow	MVP 010	UnoLine/DuoLine	HiScroll 6
Turbopump	Turbopump	Diaphragm pump	Rotary vane pump	Scroll pump
				
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Mass Spectrometry

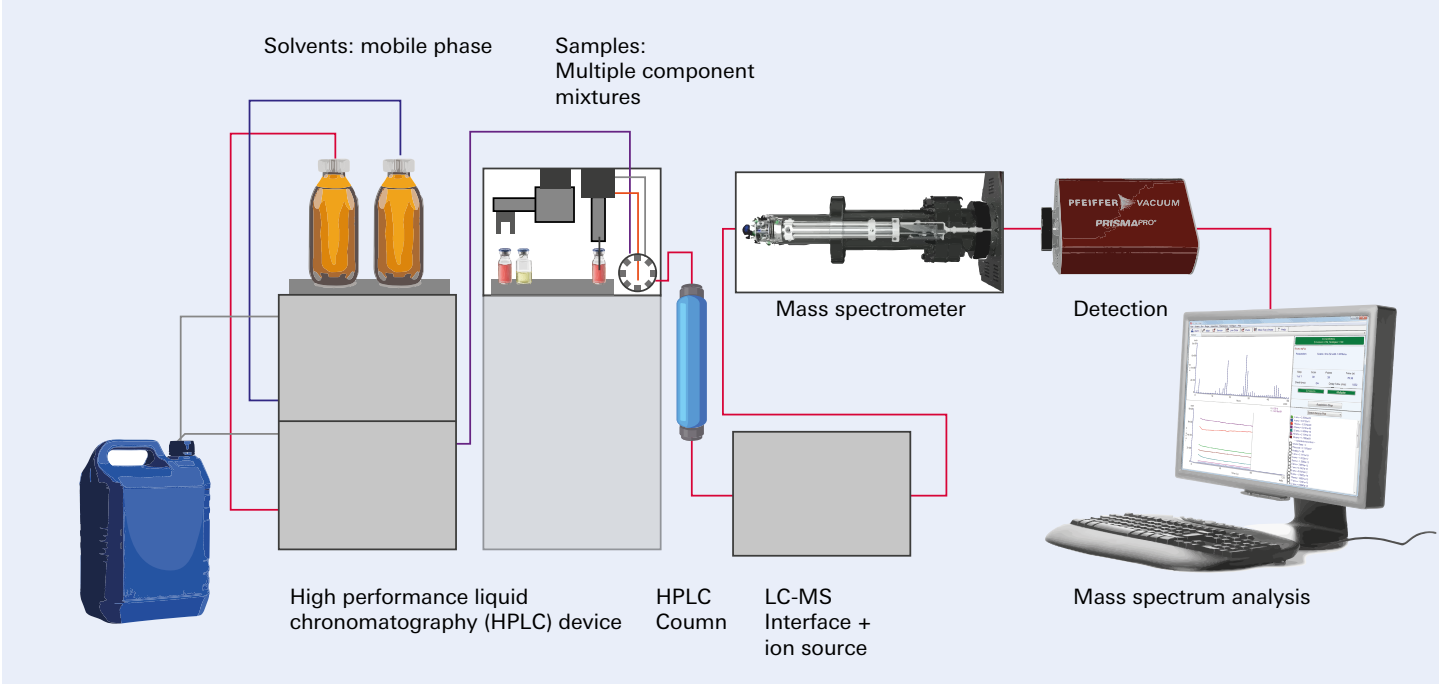
Liquid chromatography mass spectrometry (LC-MS)

Introduction

Liquid chromatography mass spectrometry (LC-MS) is an analytical method that combines the advantages from both, liquid chromatography and mass spectrometry. In combining these two techniques, identification of different substances within a test sample is accomplished. The field of application for the LC-MS is versatile, for example, clinical analysis, analysis of food, environmental and pharmaceutical residues.

How does it work?

A LC-MS system combines the physical separation capabilities of a liquid chromatograph (LC) coupled with the analysis capabilities of mass spectrometer (MS). The mixture is dissolved in a fluid, the mobile phase, which carries it through a structure holding another material, the stationary phase. The constituents of the mixture move at different speeds causing them to separate. This mixture is then introduced into the mass spectrometer which is then used to identify the individual components (masses) of the mixture. Electrospray ionization (ESI) or chemical ionization at atmospheric pressure, are often used as ionization techniques because they can be directly coupled with the LC. The most common type of mass filter is a triple-quadrupole type, which is typically one set or three which would include a „collision cell“, used to break up ions already filtered for more advanced analysis. One or more quadrupole filters can also be used in conjunction with ion traps or TOF filters for other advanced applications.



Liquid chromatography mass spectrometry (LC-MS)

Product portfolio

LC-MS Mass spectrometry requires different pressures throughout the system. In most cases a single customized SplitFlow turbopump instead of n+ 1 discrete pump can be designed to meet the specific requirements of each system. Pfeiffer Vacuum turbopumps are offering unmatched flexibility in pump design. In addition, our supreme calculation and design capability will lead to the perfect solution for your system. In addition to turbopumps, backing pumps are also required for system operation. LC-MS systems have very high flow so the main requirement of the backing pump is to handle that gas load while also getting to a pressure low enough to operate the turbomolecular pump. Pfeiffer Vacuum also offers a wide range of gauges to measure the pressures in your system and fore line connection. Several interfaces are available to ensure a proper connectivity between the different Pfeiffer Vacuum products using only one controller for all devices.

HiPace 80 Neo	Customized SplitFlow	HiScroll 6	UnoLine/DuoLine	SmartVane
Turbopump	Turbopump	Scroll pump	Rotary vane pump	Rotary vane pump
				
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Mass Spectrometry

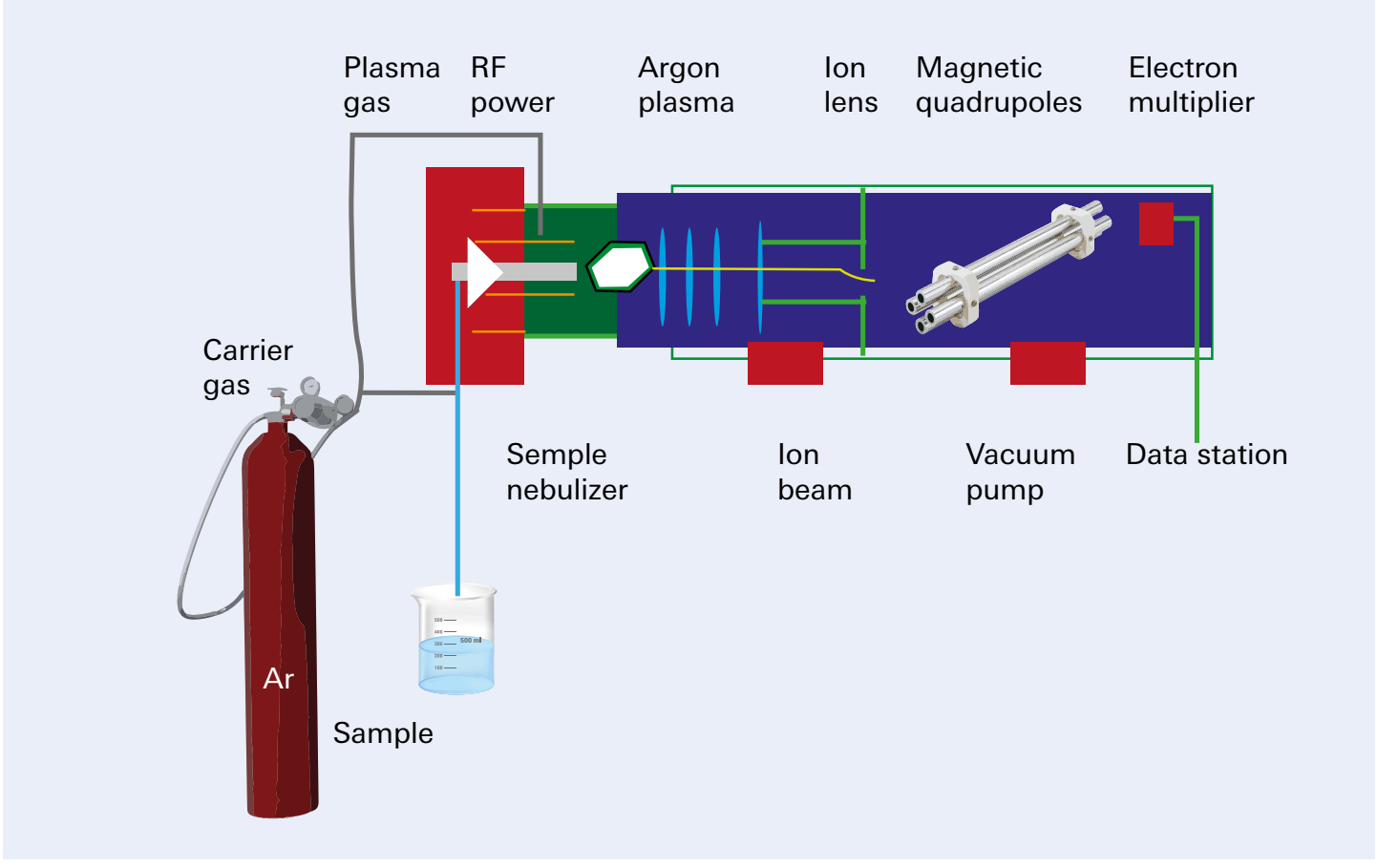
Inductively coupled plasma mass spectrometry (ICP-MS)

Introduction

ICP-MS is a type of mass spectrometry that utilizes an inductively coupled plasma to ionize a sample for the attached mass spectrometer which is typically a quadrupole system. This technique works well to show anorganic trace elements in water, soil and metals and is often used in the nuclear, medical and environmental industries to identify trace elements.

How does it work?

The ICP-MS is based on the ionization of the material that is to be analyzed with plasma at about 5,000°–10,000°C. To produce the plasma, a high frequency current is applied to ionize argon. Out of the plasma, the ions pass through two cones, which are named sampler and skimmer, to the vacuum system of the mass spectrometer. After focusing by the ion lens, the ion beam will be separated in the mass filter system.



Inductively coupled plasma masss spectrometry (ICP-MS)

Product portfolio

ICP-MS requires different pressures throughout the system. In most cases a single customized SplitFlow turbopump instead of n+1 discrete pump can be designed to meet the specific requirements of each system. Pfeiffer Vacuum turbopumps offer unmatched flexibility in pump design. In addition, our supreme calculation and design capability will lead to the perfect solution for your system. In addition to turbopumps, backing pumps are also required for system operation. ICPMS systems have very high flow so the main requirement of the backing pump is to handle that gas load while also getting to a pressure low enough to operate the turbomolecular pump. Pfeiffer Vacuum also offers a wide range of gauges to measure the pressures in your system and fore line connection. Several interfaces are available to ensure a proper connectivity between the different Pfeiffer Vacuum products using only one controller for all devices.

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Mass Spectrometry

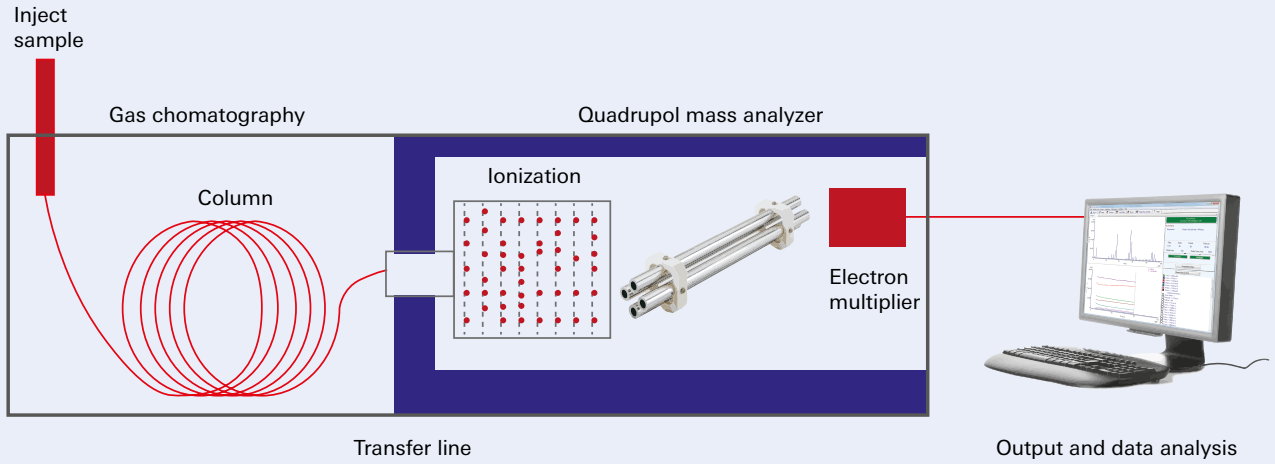
Gas chromatography mass spectrometry (GC-MS)

Introduction

Gas chromatography mass spectrometry (GC-MS) is an analytical method that combines the advantages of gas chromatography and mass spectrometry. By combining these two techniques, identification of different substances within a test sample can be achieved. The fields of application for the GC-MS is versatile and can include drug detection, airport security, environmental analysis and to identify unknown samples.

How does it work?

A GC-MS is a combination between a gas chromatograph (GC) and a mass spectrometer (MS). The gas chromatograph is used to separate the sample which is carried through a capillary by an inert gas (typically Helium) and the mass spectrometer to identify the individual components. The output of the GC is then fed to the MS where the sample is ionized and put through a mass filter (typically a quadrupole or ion trap) and then analyzed. In some cases the sample can be further analyzed by using additional quadrupoles or TOF systems.



Gas chromatography mass spectrometry (GC-MS)

Product portfolio

All modern GC-MS systems are using a turbopump to reach the required vacuum levels. Pfeiffer Vacuum manufactures a broad range of pumps with the highest available reliability combined with excellent pumping speeds for light gases. To reach the essential pressure range, a backing pump is mandatory. The typical options for GC-MS systems are Rotary vane pumps, scroll pumps or diaphragm pumps. To measure your working pressure, Pfeiffer Vacuum offers a wide range of gauges. Several interfaces are available to ensure a proper connectivity between the different Pfeiffer Vacuum products using only one controller for all devices.

In addition to standard pumps, we offer customized solutions and we also do the vacuum design and calculation for you.

HiPace 80 Neo	Customized SplitFlow	MVP 010	UnoLine/DuoLine	HiScroll 6
Turbopump	Turbopump	Diaphragm pump	Rotary vane pump	Scroll pump
				
■ Patented laser balancing technology ■ High performance lubricant ■ Compact size ■ Minimal vibrations ■ Long service life and low operating costs ■ Complete series from 10 m^3/h to 2.300 m^3/h	■ Compact desing makes for mimimum footprint ■ High pumping speed and maximum compression for all gases ■ Customized pumps from 10 m^3/h to 700 m^3/h	■ Completly dry and oil-free vacuum ■ Long diaphragm service life ■ Low noise and vibrations levels ■ Excellent operational reliability ■ Maintenance-friendly	■ Pumping speed 1.3 to 300 m^3/h ■ High operational safety thanks to integrated high-vacuum safety valve ■ Optionally available with wearfree magnetic coupling	■ Oil-free vacuum pump ■ High comfort and low vibration ■ Sustainable and energy efficient ■ Extremely quiet: <47 dB[A] ■ Very good final pressure: $<1 \cdot 10^{-2}$ hPa

Mass Spectrometry

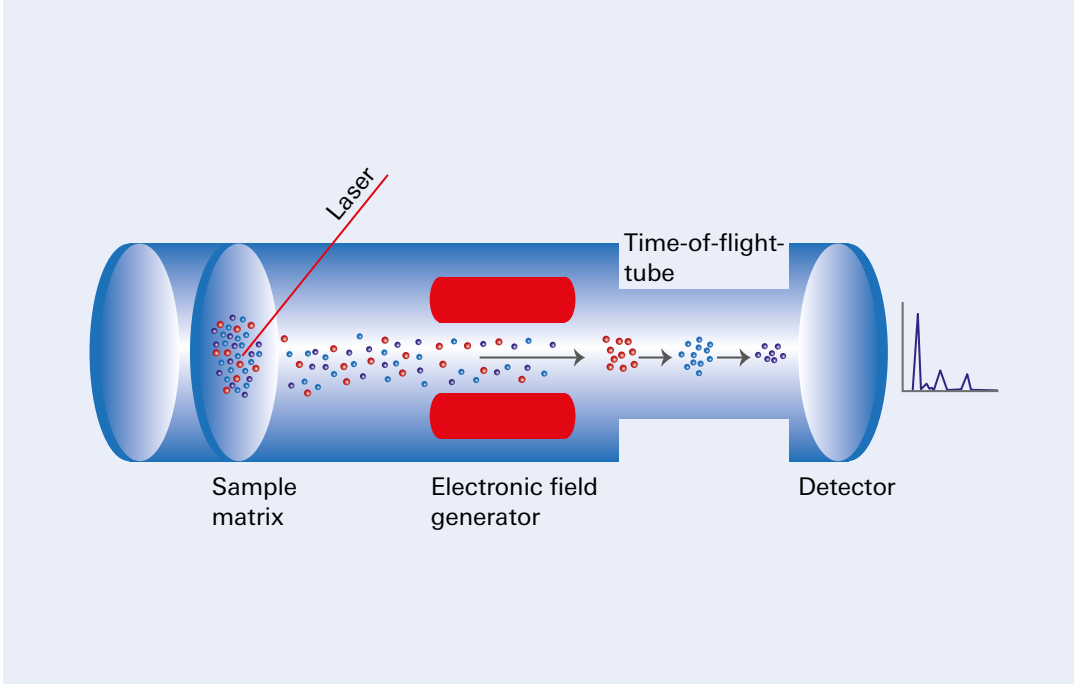
Matrix assisted laser desorption ionization (MALDI-MS)

Introduction

In times of advanced development and research, it is extremely important to have the right analytical instrument for your research. MALDI (Matrix Assisted Laser Desorption Ionization) is a soft ionization method that makes the analyte molecules into the gas phase without fragmenting or decomposing them. MALDI is used to analyze biomolecules like peptides, lipids, saccharides or other organic molecules.

How does it work?

MALDI based on the co-crystallization of matrix and an analyte with a 100–100.000 times surplus of matrix. Analyte molecules must be integrated in the crystals of the matrix when the crystals are formed. Typically successful co-crystallization needs a matrix to analyte ratio of 5000:1 (mol/mol). The matrix consists of little organic molecules, which absorb the high energy from the used laser wavelength. With short high-energy laser pulses with 2-5 Nano seconds pulse duration, the stimulation happens, which leads to explosive delamination of particles at the surface of the crystals. The matrix will travel together with the analyte molecules into the mass spectrometer and there the mass spectrometry analysis will be done. Why is MALDI used? It is a gentle ionization technique that is used when other types of ionization would fragment the sample too much.



Matrix assisted laser desorption ionization (MALDI-MS)

Product portfolio

Because of the different vacuum pressures that are needed in the different mass spectrometry stages, the turbopump is the core of the vacuum system. Therefore, Pfeiffer Vacuum offers the best customized solution, SplitFlow turbopump to evacuate different vacuum stages with only one pump. To reach the necessary pressure range, a backing pump is needed. There are various models to choose from, such as dry backing pumps like diaphragm pumps or Roots pumps but also rotary vane pumps. To have an overview of your working pressure, Pfeiffer Vacuum offers a wide product range of different gauges. With the RS-485 interface, most of the products from Pfeiffer Vacuum can communicate with each other, resulting in one controller for your entire vacuum system.

HiPace 80 Neo	**Customized SplitFlow**	**MVP 010**	**UnoLine/DuoLine**	**HiScroll 6**
Turbopump	Turbopump	Diaphragm pump	Rotary vane pump	Scroll pump
				
■ Patented laser balancing technology ■ High performance lubricant ■ Compact size ■ Minimal vibrations ■ Long service life and low operating costs ■ Complete series from 10 m^3/h to 2.300 m^3/h	■ Compact desing makes for mimimum footprint ■ High pumping speed and maximum compression for all gases ■ Customized pumps from 10 m^3/h to 700 m^3/h	■ Completly dry and oil-free vacuum ■ Long diaphragm service life ■ Low noise and vibrations levels ■ Excellent operational reliability ■ Maintenance-friendly	■ Pumping speed 1.3 to 300 m^3/h ■ High operational safety thanks to integrated high-vacuum safety valve ■ Optionally available with wearfree magnetic coupling	■ Oil-free vacuum pump ■ High comfort and low vibration ■ Sustainable and energy efficient ■ Extremely quiet: <47 dB[A] ■ Very good final pressure: $<1 \cdot 10^{-2}$ hPa

Mass Spectrometry

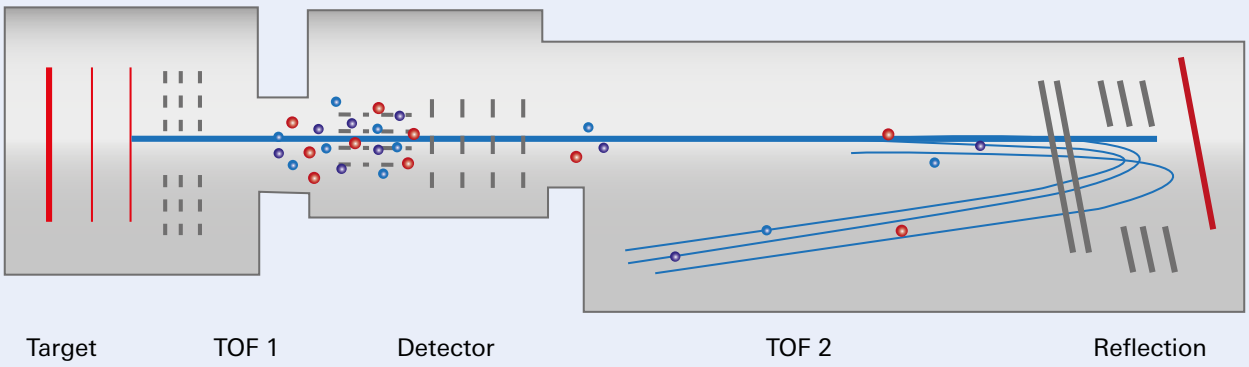
Time-of-flight mass spectrometry (TOF-MS)

Introduction

TOF-MS (Time-of-Flight Mass Spectrometry) is a method of mass spectrometry in which the mass to charge ratio is determined by the amount of time it takes to move between 2 points given a fixed amount of kinetic energy. This technique allows the measurement of very large and complex ions and means it is useful in analyzing biomolecules and large organic molecules. TOF systems are often coupled with MALDI (Matrix Assisted Laser Desorption and Ionization) which is a gentle ionization technique that also lends itself to large molecules.

How does it work?

Ions are held at one end of the flight tube and are then given a fixed amount of kinetic energy and the time is measured from when the ions are energized to when they are detected. Given the same amount of energy, the larger a molecule is, the slower it will move. In modern TOF systems ions are turned one or more times using „reflectrons“ to effectively increase the length of the flight tube and thereby the sensitivity of the TOF. The ions typically travel 1 m or more in the tube and therefore having high vacuum is critically important to the system.



Time-of-flight mass spectrometry (TOF-MS)

Product portfolio

TOF systems always require high vacuum and depending on the design and type may have multiple pressure regimes. One or more customized turbopumps may be required for an ideal performance. Typical flow rates are quite low so backing pump requirements often are not as difficult as in some other types of MS. Rotary vane pumps, Scroll pumps and Diaphragm pumps could works depending on the requirements. Pfeiffer Vacuum also offers a wide range of gauges to measure the pressures in your system and fore line. Several interfaces are available to ensure a proper connectivity between the different Pfeiffer Vacuum products using only one controller for all devices.

HiPace 80 Neo	Customized SplitFlow	UnoLine/DuoLine	HiScroll 6
Turbopump	Turbopump	Rotary vane pump	Scroll pump
			
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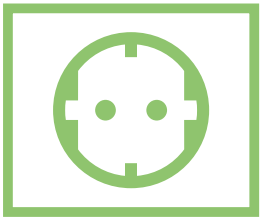
Mass Spectrometry

Products and applications

Application	HiPace – turbomolecular pumps	SplitFlow – customized solution	HiCube – turbomolecular pumping stations	HiPace M – magnetically levitated turbopumps	MVP – dry diaphragm pumps	HiScroll – dry scroll pumps	Smartvane – singel stage rotary vane pumps	Duo /Uno – rotary vane pumps	Measurement and analysis	ASM – leak detection and measurement	Valves, chambers and components
Mass spectrometry											
GCMS	■	■	■		■	■		■	■	■	■
LCMS	■	■	■			■	■	■	■	■	■
ICPMS	■	■				■	■	■	■	■	■
HLD	■	■			■			■	■	■	■
MALDI	■	■				■		■	■	■	■
RGA	■	■	■		■	■		■	■	■	■
Surface science											
STM	■	■	■			■			■	■	■
AFM	■	■	■			■			■	■	■
SPM	■	■	■			■			■	■	■
TEM	■	■		■	■	■		■	■	■	■
SEM	■	■		■	■	■		■	■	■	■
EPMA									■	■	■
Sample preperation	■	■	■			■		■	■	■	■
Material characterisation											
XRD	■	■	■			■		■	■	■	■
XRF	■	■	■			■		■	■	■	■
OES	■	■	■		■	■			■	■	■
FT-IR		■				■			■	■	■
Thermal	■	■	■		■	■		■	■	■	■
Sorption	■	■	■		■	■		■	■	■	■
Leak detection	■	■	■		■	■	■	■	■	■	■

We drive sustainable solutions

Sustainability is playing an increasingly important role in today's society, including the products we use. This also applies to mass spectrometry and the associated instruments and equipment, such as those manufactured by Pfeiffer Vacuum.



Pfeiffer Vacuum is aware of the importance of sustainability and actively strives to offer environmentally friendly solutions. An important aspect is the energy efficiency of the devices. By using energy-efficient components and innovative technologies, Pfeiffer Vacuum's products can reduce energy consumption and contribute to reducing CO_2 emissions.

Another goal is the longevity and recyclability of the products. Pfeiffer Vacuum designs its devices to have a long service life and be easy to maintain. Sustainable material selection is also prioritized to improve recyclability and minimize the use of environmentally harmful substances.

Pfeiffer Vacuum also places great emphasis on sustainability in production. By employing modern manufacturing technologies and optimizing processes, resource consumption is reduced and waste is avoided.

Furthermore, Pfeiffer Vacuum is committed to developing environmentally friendly packaging and using renewable energy sources in its facilities.

Through these sustainable measures, Pfeiffer Vacuum is contributing to making mass spectrometry, as an important technology for scientific research and industrial development, more environmentally friendly and making a positive contribution to sustainability.

Mass Spectrometry

Applications

Mass spectrometry is an extremely versatile analytical technique that is used in a wide range of applications. With its ability to identify, characterize, and quantify molecules at the molecular level, it has a tremendous impact on various fields of science, research, and industry.

Life science

One important application area of mass spectrometry lies in the life sciences. It is used for the investigation of proteins, peptides, nucleic acids, and other biological molecules. Protein identification and quantification play a crucial role in proteomics, enabling the study of disease mechanisms, drug development, and personalized medicine. Additionally, mass spectrometry contributes to the study of metabolic pathways, determination of drug metabolites, and analysis of biomarkers.

Pharmaceutical industry

In the pharmaceutical industry, mass spectrometry plays a key role in drug quality control. It enables the identification and quantification of active ingredients and their metabolites in various matrices such as tablets, capsules, and biological samples. Mass spectrometry is also used for drug-drug interaction studies, characterization of drug compositions, and determination of purity grades.

Environmental analysis

In environmental analysis, mass spectrometry contributes to the monitoring and analysis of environmental pollutants. It enables the detection and quantification of heavy metals, organic compounds, and persistent organic pollutants in water, soil, and air. This information is crucial for assessing environmental quality, identifying sources of contamination, and developing environmental remediation measures.

Food industry

The food industry also relies on mass spectrometry for various applications. It is used for the identification of residues of pesticides, antibiotics, and other contaminants in food samples. Authenticity testing of food, determination of additives, and analysis of flavor compounds are additional applications. Mass spectrometry contributes to ensuring food safety and quality assurance.

Forensics

In forensics, mass spectrometry is used for the identification and characterization of substances in forensic samples. It supports drug analysis, forensic toxicology, investigation of fire and explosion residues, and analysis of chemical traces at crime scenes. Mass spectrometry provides forensic experts with important information to uncover criminal activities and identify perpetrators.

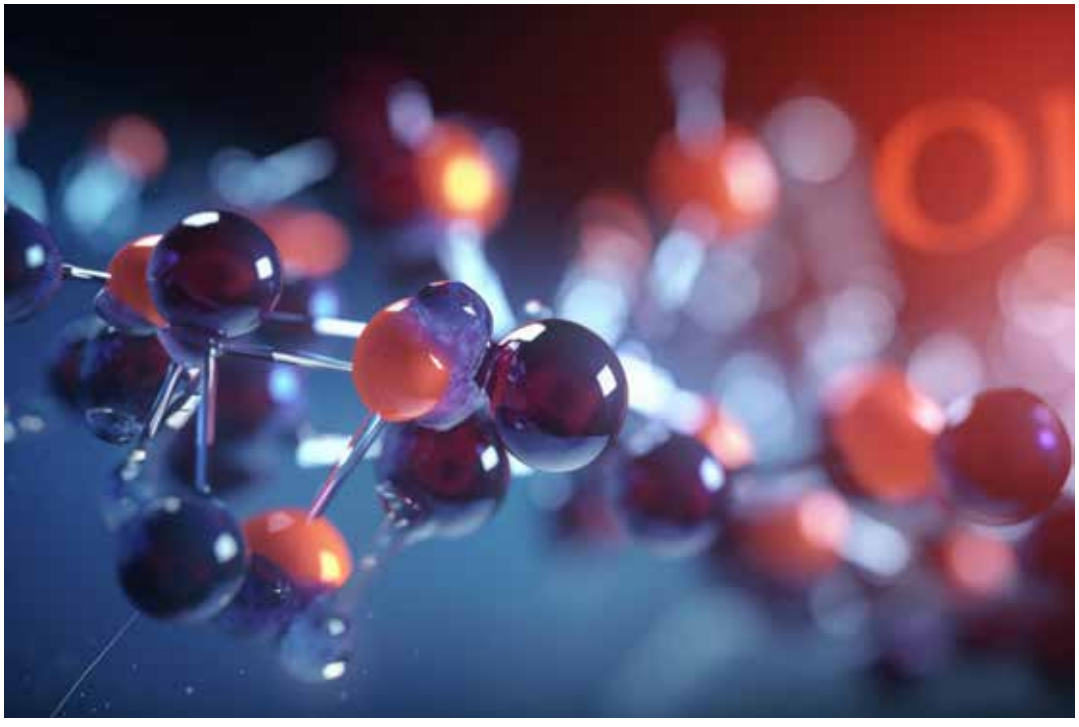
Material science

Furthermore, mass spectrometry is employed in material research and development. It enables the characterization of materials at the molecular level, investigation of surface properties and modifications, analysis of layers and coatings, and determination of the chemical composition of material samples. This is of great importance for the development of new materials, quality assurance, and material analysis.

Petrochemical industry

Mass spectrometry also finds application in the petroleum and petrochemical industry, criminology, archaeology, geology, atmospheric research, and many other fields.

Overall, mass spectrometry is an extremely powerful analytical technique that covers a wide range of applications. Its ability to identify, characterize, and quantify molecules with high precision has made it an indispensable tool in modern science, research, and industry. Through continuous development and innovation, mass spectrometry remains a driving force for new insights and advancements in numerous disciplines.



Pfeiffer Vacuum Service

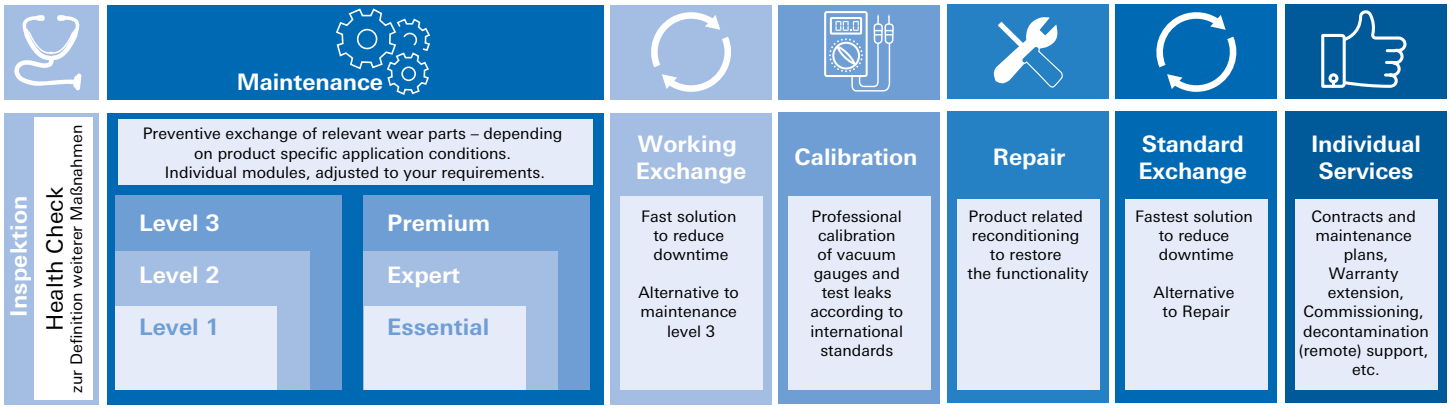
Our services – your advantages

Each customer places its own particular demands on its products, and these may also be influenced by application-specific parameters. Our flexible service concept, with a focus on preventive services, offers just the right solution for you.

Preventive maintenance – avoid downtimes

With our preventive service concept, we can recommend service intervals tailored to each product. The aim is to avoid failures and to carry out planned and predictable servicing.

Maintenance level 1 includes fluid changes and contributes significantly to the good working order of the product. **Maintenance level 2** also includes replacement of all wear and tear parts. In **maintenance level 3**, all wear and tear parts of the product are replaced and the product is overhauled. In order to keep downtimes to a minimum, we offer temporary replacements for many of our products for the duration of maintenance. We provide an equivalent **replacement product** that our customers can start using immediately.



Services at a glance

- User training and product training
- Pfeiffer Vacuum original spare parts and tools
- Troubleshooting and advice from our technical support team
- Comprehensive on-site service by our service technicians
- Maintenance and repair in our service centers worldwide
- Individual service agreements
- Replacement products
- Calibration service for measuring devices and helium test leaks

Spare parts – original parts increase life expectancy

Pfeiffer Vacuum's spare parts and tools are defined early in the product development stage to ensure their proper fit and quality.

Every improvement to our serial products is also transferred to our spare parts. This means products are brought up to state of the art status after undergoing maintenance level 3 or a repair.

Advice – to assist you with any questions you may have

In addition to our individual concepts and the quality of our replacement parts, it is our employees and personal contact that give our service its special touch.

Technical support – competent advice from the experts

Since not everything about our products is self-explanatory and questions can arise both before and after purchase, Pfeiffer Vacuum's Technical Support is available to assist our customers.

Each member of our team specializes in a specific area of our portfolio to enable them to assist our customers competently with technical questions relating to our products. Our team also works closely with our developers and application experts.

Field service technicians on site

From commissioning new vacuum components and systems to troubleshooting, and from maintenance to repairs, we offer our customers a comprehensive range of on-site services. Our service locations ensure customer proximity and short-term assistance in emergencies.

Service agreements – individually tailored to your project

We offer project-specific service agreements so that our customers can plan maintenance or service interventions over a long term. These agreements can be made at a later date or as early as during the project planning stage. In order to take our customers' differing needs into account, agreements may include all or just some of the services we offer.

Components and valves

The connection in your vacuum system

A vacuum system is made up of a variety of individual parts which are combined to form a single unit. Pfeiffer Vacuum offers standard solutions, but also component modifications or a customized solution to fit your needs perfectly.

Your advantages and benefits

- A direct contact for you and your projects
- Proactive support and competent advice
- Convenient ordering

- Short delivery times
- High delivery reliability
- High security of supply

- More than half a million parts in stock
- High uptime
- Cost saving- no keeping stock necessary

www.vacuum-shop.com

- Convenient online vacuum component ordering any time
- Information about your prices, delivery times and terms

Components

Valves

Feedthroughs

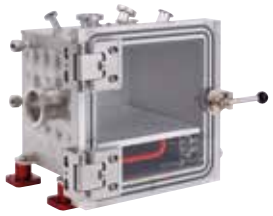
Manipulators

Custom vacuum chambers

Individually designed chambers for your vacuum applications

Due to our many years of experience, we can provide professorial quidance for system specifications, design and engineering.

Our physicists, designers, project managers and production specialists have extensive experience in many applications from all market segments. The tasks are based on your requirements: our starting point on the path to a finished product can range from a rough sketch to a complete set of blueprints.

High vacuum chambers	Advantages	Benefits
	Preconfigured design	Cost and time savings due to lower design expenses
	Proven, tough design	Reliable and safe
	Customized ports	Individual adaptation to your processes

High vacuum chambers	Advantages	Benefits
	Preconfigured design	Cost and time savings due to lower design expenses
	Proven, tough design	Reliable and safe
	Customized ports	Individual adaptation to your processes

High vacuum chambers	Advantages	Benefits
	Preconfigured design	Cost and time savings due to lower design expenses
	Modularly expandable	Maximum flexibility at all times
	Customized ports	Adaptable individually to your application

High vacuum chambers	Advantages	Benefits
	Individual design	Can be adapted optimally to your process
	High quality materials	Best quality and long life
	Robust design	Reliable and safe
	Project engineering and construction by qualified and experienced project managers	Time saving

Your Success. Our Passion.

We give our best for you every day – worldwide!

Are you looking for your optimized vacuum solution? Please contact us:

Pfeiffer Vacuum GmbH
Germany
T +49 6441 802-0

Follow us on social media
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