World Map of Shimadzu Sales, Service, Manufacturing, and R&D Facilities
Shimadzu’s Total Support for Food Safety

Shimadzu provides total support for food safety, whether it is farm to fork or bait to plate. As a leading manufacturer of a wide range of analytical instruments, Shimadzu undertakes development of new instruments and technologies, and provides comprehensive service support in order to keep up with changing market demands.

In addition to offering analytical instruments and testing machines, Shimadzu provides total support that includes the provision of information for the food safety community, training at workshops and seminars, and instrument maintenance management.

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Analysis of Residual Pesticides

Food knows no borders. A pesticide used in one country may be banned in another country, or even banned around the world because of health risks. This has resulted in increased testing of pesticides in agricultural products as there are over 1,000 known pesticides. Shimadzu offers a wide range of instruments for pesticide testing, from GC and LC with specific detectors to single and triple quadrupole mass spectrometers.

**MRM Analysis of Residual Pesticides in Food (GC-MS/MS)**

Analysis of 360 pesticides in apple extract in 10 minutes using a GCMS-TQ8040 with Smart MRM.

Finally, a triple quadrupole GC-MS/MS Smart enough for everyday use in your laboratory. The Shimadzu GCMS-TQ8040 is the first triple quadrupole with Smart Productivity for high-efficiency sample throughput, Smart Operation for quick and easy method development, and Smart Performance for low detection limits and Scan/MRM. These three smart technologies contribute to Smart MRM and provide the most accurate, cost-effective, and easy-to-use triple quadrupole GCMS you have ever imagined.

**Features**

**Smart productivity**
- 400+ compounds in one run
- Smart MRM software
- Twin Line MS Kit

**Smart operation**
- MRM optimization tool
- Smart Database series
- Automatic Method Creation

**Smart performance**
- Scan/MRM acquisition mode
- High-speed scanning
- Automatic Adjustment of Retention Time (AART).

So Smart it almost runs itself!

**Options**

**Smart Pesticide Database**
The Smart Pesticide Database includes optimized transitions and collision energies, CAS registry numbers, and Retention Indices (RI) for hundreds of pesticides. Select from pre-registered compounds in one database, or add you own optimized transitions. Select the compounds to be analyzed, and Smart MRM builds the MRM or Scan/MMRM acquisition method from the “Smart Database” with a push of a button.

**Pesticide Quick-DB**
The software package contains Scan/MMRM and Scan/SIM acquisition methods, and pre-stored calibration curves for semi-quantitative results for 480 pesticides within one hour of installation.

**Features**

**High sensitivity**
The high-performance ion source improves and lowers the minimum limits of detection and quantitation for measurements of trace components. A reduced absolute sample injection volume prevents contamination of the insert.

**Simultaneous Scan/SIM measurements**
During high-sensitivity SIM measurements of trace components, Scan measurements are performed on unknown components missed by SIM.

**Retention time correction**
Significantly reduces the workload for multicomponent simultaneous analysis.
Liquid Chromatograph Mass Spectrometer (LC-MS/MS)

LC-MS/MS MRM (Multiple Reaction Monitoring) analysis allows for rapid and sensitive detection of pesticides in complex matrices. An example of simultaneous multi-residue multi-class pesticide analysis is shown below.

**Triple Quadrupole Mass Spectrometer**
**LCMS-8050**

**Features**
- **Ultra-high speed**
  - Ultra-fast polarity switching at 5 msec.
  - Ultra-fast scanning at 30,000 u/sec.
  - Ultra-fast MRM transition speeds at 555 MRMs/sec.
- **High sensitivity**
  - Newly improved ion optics and collision cell provide higher MRM and Scan sensitivity, which expands the potential range of LC-MS/MS applications.
- **User-friendly**
  - Minimize instrument downtime with easy maintenance.
  - A single-vendor solution of LC and MS provides seamless operation.
  - In addition, it provides for simplistic MRM optimization.

**Liquid Chromatograph Mass Spectrometer (LC-MS)**

Single quadrupole LC-MS enables rapid and sensitive quantitative analysis of a wide variety of analytes. An example of vitamin analysis is shown below.

**Single Quadrupole Mass Spectrometer**
**LCMS-2020**

Rapid polarity switching (15 msec) allows detection of both positively and negatively charged species. Excellent linearity (R2 > 0.99) and 1-50 part-per-billion quantitation limits were obtained.

Shimadzu’s Total Support for Food Safety
Analytical and Testing Instruments for Food Safety
Analysis of Residual Pesticides

Analysis of Residual Pesticides (GC)
Capillary GC can be utilized for the analysis of residual pesticides in foods. Using a selective detector such as FPD, FTD or ECD offers highly sensitive analysis of trace pesticides.

Liquid Chromatograph (LC)
GC or GC-MS techniques may not be suitable for analysis of residual pesticides that thermally decompose or have a highly polar chemical structure. In contrast, an HPLC equipped with a photodiode array detector can acquire reliable chromatograms with spectral information for building libraries to compare compounds. The Shimadzu carbamate analysis system incorporates derivatization technologies to achieve high-sensitivity, selective analysis of N-methyl carbamate pesticides.

Features

High-sensitivity detection
The FPD (Flame Photometric Detector) provides powerful detection of phosphorus and sulfur-based pesticides. For example, the minimum detectable quantities of phosphorus and sulfur are 55 fgP/s and 3 fgS/s, respectively.

Higher analytical efficiency and productivity
With the addition of a new cooling fan and superior air flow optimization, the oven cooling speed has dramatically improved (450 °C -> 50 °C cooling time: 3.4 minutes). A self-diagnostic function prevents failure by confirming proper operation and periodic diagnostics prevent unexpected downtime.

Multiple detectors in a single GC
Three detectors can be simultaneously mounted in the GC-2010 Plus: ECD, effective for chlorinated and pyrethroid-based pesticides; FPD, effective for sulfur- and phosphorous-based pesticides; and FTD, effective for nitrogen- and phosphorous-based pesticides.

Gas Chromatograph GC-2010 Plus

High-Performance Liquid Chromatograph Prominence Series Carbamates Pesticides Analysis System

Features

Rapid injection
An injection time of 10 seconds for a 10 µL sample enhances analysis efficiency.

High sensitivity and linearity over a broad range
Upgraded optical and electrical systems reduce noise for lower detection limits and ensure simultaneous analysis of major components and trace components.

Low sample carryover
Platinum coating minimizes the adsorption of sample components on to the needle surface.
Analysis of Mycotoxins

Simultaneous Analysis of Mycotoxins (LC-MS/MS)

LC-MS/MS is effective for analysis of mycotoxins in complex matrices. Shown is an example of simultaneous analysis of 45 mycotoxins by LC-MS/MS. All compounds, including positive and negative ions, were separated and detected with high sensitivity within 9 minutes. For analysis of mycotoxins with high sensitivity, eliminating carryover is indispensable. Modified rinse methods using the SIL-30AC autosampler can eliminate carryover of fumonisin.

In a batch analysis of multiple samples, compounds with greatly differing polarities are frequently analyzed together. In cases such as this, sufficient rinsing between samples to reduce carryover may not be achieved using one type of rinse solution. To combat this, the SIL-30ACMP design incorporates sample-contacting materials to which components are less likely to adsorb, and a multi-solvent internal and external needle and loop rinsing protocol designed to reduce carryover to less than 0.0015%.

Analysis of Aflatoxins (UHPLC)

The analysis of aflatoxins (B1, B2, G1 and G2) is very important from a food safety perspective due to concerns about adverse effects on human health. The Nexera Ultra High Performance Liquid Chromatograph achieves high-resolution analysis of aflatoxins in less than four minutes. The RF-20Axs high-sensitivity fluorescence detector allows direct analysis of aflatoxins at trace levels (ppt) without any derivatization.

Ultra High Performance Liquid Chromatograph Nexera X2 with RF-20Axs

Chromatogram of 45 mycotoxins at 50 ppb (2 ppb for aflatoxins and ochratoxines)

Chromatogram of 45 mycotoxins at 50 ppb (2 ppb for aflatoxins and ochratoxines)
Identification and Observation of Microorganisms

In the event of food poisoning, identification of the causative factor is extremely important in determining the path of infection, prescribing treatment and preventing recurrence. Shimadzu’s iDPlus microorganism identification platform provides rapid identification of microorganisms in food.

Identification of Microorganisms (MALDI-TOF-MS)

In order to prevent pathogenic germs from contaminating food sources, it is essential to identify them quickly and reliably in order to allow for proper control measures. A microorganism identification system using the AXIMA MALDI-TOF MS enables direct measurement of cultured microorganisms and identification within two minutes.

**What is Microorganism Identification by MALDI-TOF MS?**

Species-specific mass spectral patterns from microorganisms can be obtained by direct measurement of microorganisms using MALDI-TOF MS. Identification of microorganisms can be performed by matching these collected spectra to the database. This is a fast, easy and reliable method for identification of microorganisms.

**AXIMA iDPlus Microorganism Identification System**

**Features**

- **Quick and easy analysis**
  Three steps from sample preparation to identification.
  The microorganism identification process is finished within two minutes after starting the analysis.

- **Highly accurate identification**
  Microorganism identification by MALDI-TOF MS is a well-established technique with a low number of false positives.

- **Applicable for a wide range of microorganisms**
  Capable of classifying/identifying gram-positive and gram-negative bacteria, yeasts, fungi and spores. iDPlus identifies microorganisms by family, genus, species, and subspecies.

- **Database customization**
  Easily register new microorganisms in the database, which allows rapid development of a high-quality database.

- **Low operational cost**
  Analysis can be performed for pennies per sample compared to expensive traditional techniques.

- **Expanded research capabilities**
  iDPlus is not limited to microorganism identification. Relectron mode and MS/MS functionalities enable a true research platform.
Analysis of Veterinary Pharmaceuticals

Veterinary pharmaceuticals are used in the diagnosis, cure, mitigation, treatment, and prevention of diseases in animals as well as in the promotion of growth. However, there is increasing concern about these drugs entering the food chain and their effects on the human body. These drugs are categorized in many classes, such as anabolic hormones, anthelmintics, antibiotics, beta-agonists, coccidiostats, corticosteroids, nonsteroidal anti-inflammatory drugs (NSAIDs), and sedatives. Below are a few examples of veterinary pharmaceutical analyses.

Analysis of Beta-agonist (LC-MS/MS)

Beta-agonists can be added to animal feed to work as growth promoters due to their ability to increase muscle mass and decrease fat deposition. However, due to their adverse effects on human health, these compounds have been banned for growth-promoting purposes in farm animals by regulatory agencies worldwide.

Analysis of Malachite Green and Leucomalachite Green in Fish (LC-MS)

Malachite green is an organic dye used as an antimicrobial medication to treat white-spot disease and tail rot in aquarium fish. Its use is not authorized for farmed fish in some countries. As malachite green is metabolized to leucomalachite green in the human body, the simultaneous analysis of these two components is required. Below is an example of the LC-MS analysis of malachite green and leucomalachite green.

Analysis of Chloramphenicol in Honey (LC-MS)

Chloramphenicol is effective against many microorganisms. However, due to its serious side effects in humans, it is only used against potentially fatal infectious diseases. Chloramphenicol has not only been detected in fish and meat, but cases are occasionally reported in milk. Below is an example of the LC-MS analysis of chloramphenicol in milk.

Analysis of Anabolic Steroids (On-line SPE-LC-MS/MS)

The use of natural and synthetic hormones to increase the weight of meat-producing animals is prohibited by regulatory agencies worldwide in order to protect consumers from the harmful effects of digesting hormone residues and their metabolites. Compliance with this legislation is monitored by the screening of a large number of animals every year.

Chromatogram of honey samples unsiked and spiked with chloramphenicol

Chromatogram of honey samples unsiked and spiked with chloramphenicol

Chromatogram of honey samples unsiked and spiked with chloramphenicol

MS spectrum from LC-MS analysis of chloramphenicol

Shimadzu’s Total Support for Food Safety
Analytical and Testing Instruments for Food Safety

9
Analysis of Food Additives

A wide variety of additives are used in foods such as preservatives, flavor enhancers, coloring agents and antioxidants. Strict monitoring of food stuffs is essential to detect the use of prohibited chemicals. Each country assigns a unique number or code of approved chemicals for that country. Shimadzu offers a wide range of products for detecting the prohibited chemicals, whether they were added intentionally or through contamination.

Analysis of Dicyandiamide and Melamine in Milk Powders (LC-MS/MS)

Melamine was found to be used as a protein-rich adulterant in pet food in 2007, and then in infant formula in 2008 in China. The outbreak of the melamine scandal that killed many dogs and cats as well as led to the deaths of six infants and illness of many others caused panic and great concerns worldwide. Recently, low levels of dicyandiamide (DCD) residues were found in milk products from New Zealand. Instead of being added directly as an adulterant, the trace DCD found in milk products was explained to be relating to the grass "contaminated by DCD”. Dicyandiamide has been used to promote the growth of pastures for cows grazing.

Analysis of Preservatives in Food (UV)

Below are examples of the analysis of food samples spiked with preservatives.

Analysis of Sudan Dyes in Curry Powder (LC)

Sudan dyes are oil-soluble synthetic dyes used in industrial products. Their use is not authorized in food products in some countries. This is an example of LC analysis of Sudan dyes in curry powder.

UV-VIS Spectrophotometer UV-1800

Features

- High resolution
  - 1 nm resolution provides for high data reliability.
- Enhanced security
  - Functions can be restricted according to user level.
- Instrument validation
  - Automatic/semi-automatic validation of wavelength accuracy and wavelength reproducibility.
Analysis of Toxic Metals

Toxic metals (arsenic, lead, cadmium, etc.) in foods must be controlled down to low concentration levels. Shimadzu atomic absorption spectrophotometers and ICP emission spectrometers offer highly sensitive analysis of trace elements in foods. Shimadzu’s product lineup also includes X-ray fluorescence spectrometers that can perform elemental analysis without sample pretreatment. These instruments are ideal for screening analysis and emergency analysis.

Analysis of Cd and Pb in Food Additives (AA)

Analysis of cadmium (Cd) and lead (Pb) in α-cyclodextrin (cyclic oligosaccharide), a substance used in functional foods, pharmaceuticals, cosmetics, etc. The analysis was conducted by the AA-7000 atomic absorption spectrophotometer.

Atomic Absorption Spectrophotometer AA-7000

Features

- Measures from trace levels to high concentrations
- Automatic switching between flame and furnace measurements. A single instrument handles analysis from ppb to ppm levels.
- Sophisticated automation
- Automation functions enhance analysis efficiency. For instance, automatic searching sets the optimal gas flow rate and burner height for flame measurements. Also enables automatic dilution and re-measurement for over ranged samples compared to the calibration curve. The autosampler allows automatic addition of spikes, matrix matching, and dilutions (300x) with true mixing capability.
- Advanced safety technology
- World’s first AA with vibration sensor to automatically extinguish the flame in case of an earthquake. Automatic gas-leak checks and safety functions prevent misuse of the wrong burner head.

Analysis of Trace Element Contamination in Fish Sample (ICP)

Fish Protein Certified Reference Material for Trace Metals (DORM-4) was used as fish sample. The Shimadzu ICP-9800 Series can provide a rapid method to simultaneously analyze trace elements in fish. The results show excellent correlation with the certified reference material.

ICP Emission Spectrometer ICPE-9800 Series

Features

- Simultaneous multi-element quantitative analysis
- Multiple elements can be analyzed simultaneously.
- High sensitivity and wide dynamic range
- Simultaneous analysis of trace components and major components
- Low running costs
- Shimadzu’s unique mini torch halves argon gas consumption.

<table>
<thead>
<tr>
<th>Element</th>
<th>Measured Value (1) (mg/kg)</th>
<th>Measured Value (2) (mg/kg)</th>
<th>Certified Value (mg/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>As</td>
<td>7.07</td>
<td>6.83</td>
<td>6.80 ± 0.64</td>
</tr>
<tr>
<td>Cd</td>
<td>0.312</td>
<td>0.312</td>
<td>0.306 ± 0.015</td>
</tr>
<tr>
<td>Cr</td>
<td>1.74</td>
<td>1.74</td>
<td>1.87 ± 0.16</td>
</tr>
<tr>
<td>Cu</td>
<td>15.5</td>
<td>15.6</td>
<td>15.9 ± 0.9</td>
</tr>
<tr>
<td>Fe</td>
<td>3.17</td>
<td>3.18</td>
<td>341 ± 27</td>
</tr>
<tr>
<td>Ni</td>
<td>1.17</td>
<td>1.18</td>
<td>1.36 ± 0.22</td>
</tr>
<tr>
<td>Pb</td>
<td>0.392</td>
<td>0.439</td>
<td>0.416 ± 0.053</td>
</tr>
<tr>
<td>Se</td>
<td>3.36</td>
<td>4.46</td>
<td>3.56 ± 0.34</td>
</tr>
<tr>
<td>Zn</td>
<td>50.3</td>
<td>51.9</td>
<td>52.2 ± 3.2</td>
</tr>
</tbody>
</table>

Fish Protein Certified Reference Material for Trace Metals (DORM-4) was used as fish sample.
Inspection and Analysis of Foreign Matter

Foreign matter can become mixed with food products during the production process for a variety of reasons. The discovery and identification of foreign matter and ascertaining its source are essential for maintaining food safety. Shimadzu’s non-destructive testing and analytical technologies can be used to detect foreign matter that is not externally visible and analyze for the elemental or molecular components.

**Analysis of Inorganic Foreign Matter (EDX)**

An energy-dispersive X-ray fluorescence spectrometer (EDXRF) permits the easy and rapid identification of inorganic foreign matter adhering to, or mixed into, food products. Below is an example of the qualitative analysis of a metal fragment on chocolate.

![Quantitative analysis results](image)

**Features**
- Large sample chamber
  - Accepts samples of up W300 x D275 x H100 mm.
- Easy operation
  - Automates complex set-up operations. Even novices can easily conduct accurate measurements.

**Analysis of Organic Foreign Matter (FTIR)**

The Fourier transform infrared (FTIR) spectrophotometer measures the organic foreign matter spectrum and compares it with library data to identify the foreign matter. The example below shows the analysis of contamination on a frozen pizza. Some of the foreign substance was scraped off the frozen pizza, and the infrared spectrum was measured using a transmission infrared microscope. The spectrum of this foreign object was similar to that of a fluororesin.

![Infrared spectra of contaminant and fluororesin](image)

**Features**
- High sensitivity
  - High S/N ratio above 60,000:1. Microscope permits analysis of foreign matter in the micron size range.
- Foreign matter analysis program as standard
  - Powerful support for foreign matter analysis. Includes more than 300 spectra of recognized foreign matter.
- Easy maintenance
  - Automatic dryer protects the optical system. Eliminates superfluous maintenance.
Food Processing

Food processing takes a farmed product and turns it into an edible, marketable product that may have a longer shelf life. Examples of these processes are baking, canning, fermenting, grilling, heating, hydrolysis, and roasting. During these processes, undesirable and even toxic compounds can form. Or cross-contamination can occur from the big eight allergens of egg, fish, milk, peanuts, shellfish, soy, tree nuts, and wheat to non-allergen foods.

Analysis of Acrylamide in Potato Chips (LC-MS/MS)

Acrylamide was found to form in fried foods like potato chips via the so-called Maillard reaction of amino acid asparagine and reducing sugar glucose at a higher temperature (120°C). The health risk of acrylamide present in many processing foods became a concern immediately, because it is known that the compound is a neurotoxin and a potential carcinogen to humans.

Analysis of Styrene Leached from Polystyrene Cups (Headspace-GCMS)

Worldwide studies have revealed the negative impacts of household disposable polystyrene cups on human health and the environment. Styrene is considered as a possible human carcinogen by the WHO and International Agency for Research on Cancer (IARC). Migration of styrene from polystyrene cups containing beverages has been observed. Styrene enters into our body through the food we eat, mimics estrogens in the body, and can therefore disrupt normal hormonal functions. This could also lead to breast and prostate cancer.

Shimadzu’s Total Support for Food Safety

Analytical and Testing Instruments for Food Safety
Analysis of Flavor & Texture

Analysis of Off-Flavor (Headspace GC-MS)

2,4,6-Trichloroanisole (TCA) is a natural compound known as the chief cause of musty smell in wine. Below is an analysis of wine for 1 ng/L of TCA by headspace-trap-GC-MS. The headspace-trap method is 10 times more sensitive than headspace alone when coupled to a GC-MS.

![SIM Chromatogram of (TCA) in wine measured with HS-Trap GC/MS at 1 ng/L]

Flavor Release Evaluation Kit (EZ Test-GC-MS)

Evaluation of flavor and texture with each “chew” is possible. The EZ Test measures the texture with each “chew” as the flavors are released into the sampling bag. The flavors are extracted from the bag with a SPME sample needle and injected into the GC-MS for flavor analysis.

Application System of Headspace-Trap GC-MS

GCMS-QP2010 Ultra with HS-20 Trap

- **Features of HS-20 Trap**
  - **Multiple modes**
    - Loop Mode captures fixed volume for transfer to GC.
    - Multiple Headspace Extraction (MHE) captures the sample from the same vial multiple times, resulting in up to ten GC-MS analyses. Trap Mode increases sensitivity by a factor of 10 by trapping the headspace.
  - **Automation**
    - 90-position sample tray holds 10 or 20 mL vials. A 12-position equilibration oven prepares upcoming samples. Optional barcode reader available.

Flavor Release Evaluation Kit EZ Test-GC/MS

- **Features**
  - Evaluation of texture and flavor with each “chew”
  - Eliminate off-flavor and off-texture of foods.
  - Research & develop new textures and flavors which vary with each “bite”.

![Features of HS-20 Trap]

![Flavor Release Evaluation Kit EZ Test-GC/MS]
Prevention of Defects in Packaging

Testing the strength and functionality of packaging materials is essential to ensure food products reach consumers fresh and undamaged. To aid the development and quality control testing of packaging materials, Shimadzu analytical and testing technologies allow the analysis of residual solvents in packaging materials, strength testing of adhesive seals, and checks for pin holes in packaged products.

Adhesive Strength Testing (Strength Tester)
A wide range of materials is used for packaging, including aluminum and other metals and non-metallic materials such as paper and plastic. According to their application, these materials must meet certain tensile, compression, and bending strength requirements, and if an adhesive is used, adhesive strength requirements. In the examples below, adhesive strength results for liquid-filled pouch and dry snack package specimens are shown. In both instances, the adhesives meet the requirements of being strong enough to protect the contents, but weak enough so that the contents can easily be accessed by consumers.

EZ Test Universal Testing Machines

Features
- Comprehensive range of jigs
  - Diverse strength testing: peeling, tensile, shear, bending, compression, etc.
- Measures brittle and elastic samples
  - 5 kN max. capacity, 920 mm stroke (long-type).
- Food texture evaluation
  - Objective testing which analyzes the consistency and mouth feel of foods.

Residual Solvent Analysis (Headspace GC)
Quality control of residual organic solvents is required, as the manufacture of food packaging materials and containers involves the use of organic solvents in printing inks and adhesives. These components can be analyzed by headspace GC or by diluting in a solvent and directly injecting this sample solution into a GC instrument.

Gas Chromatograph Headspace Analysis System

Features
- High sensitivity
  - High-sensitivity analysis of volatile components (low-boiling-point components).
- Easy maintenance
  - No non-volatile components enter the GC.
- Reduced analysis time
  - Faster analysis than direct-injection GC for liquid samples containing high-boiling-point components.
List of Analytical and Testing Instruments for Food Safety

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<tr>
<th>Instrument Type</th>
<th>Residual Pesticides</th>
<th>Mycotoxins</th>
<th>Veterinary Pharmaceutical</th>
<th>Food Additive</th>
<th>Toxic Metals</th>
<th>Inspection and Analysis of Foreign Matter</th>
<th>Off-Flavor</th>
<th>Prevention of Defects in Packaging</th>
<th>Region and Type Identification</th>
<th>Identification and Observation of Bacteria</th>
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<td>Gas Chromatograph (GC)</td>
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<td>Atomic Absorption Spectrophotometer (AA)</td>
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<td>ICP Emission / Spectrometer (ICP, ICP-MS)</td>
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<td>X-Ray Fluorescence Spectrometer (XRF, EDX)</td>
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<td>Universal Testing Machine (AG, EZ Test)</td>
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<td>MALDI-TOF Mass Spectrometer (MALDI-TOF-MS)</td>
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Shimadzu Balances

UniBloc family of balances

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