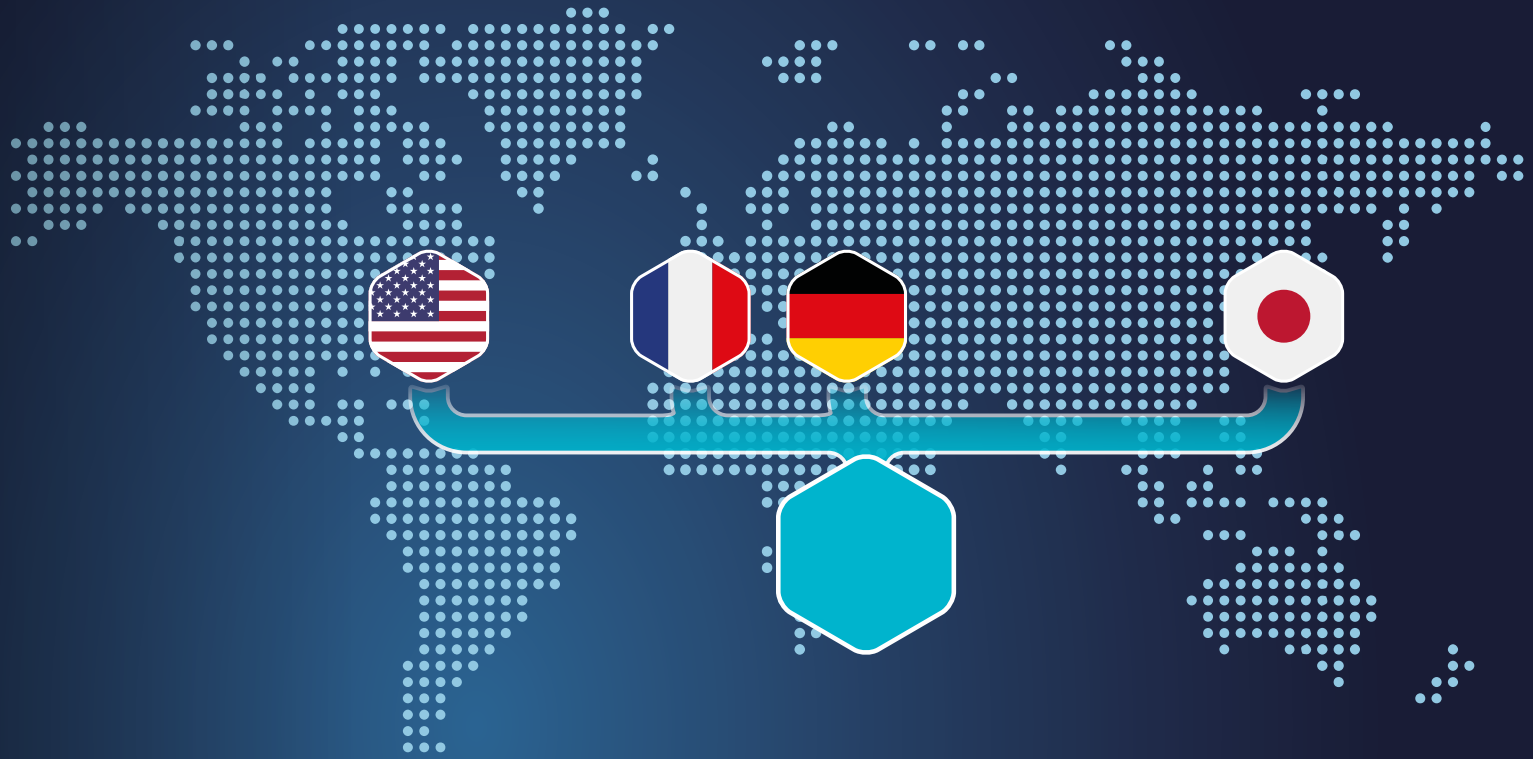
MICROTRAC
PARTICLE CHARACTERIZATION

BELSORP MAX X

BET SURFACE AREA AND PORE SIZE DISTRIBUTION ANALYZER

HIGH-END ADSORPTION. SMALLEST FOOTPRINT. UNRIVALED PERFORMANCE.

part of VERDER



MICROTRAC

PARTICLE CHARACTERIZATION AT ITS BEST

Microtrac is your preferred partner for the comprehensive characterization of particulate systems. We provide our customers with advanced technologies to obtain consistently reliable results. Innovation and quality are at the core of everything we do.

As part of Verder Scientific, we provide worldwide support through a network of subsidiaries and distributors.

Three Centers of Excellence

MICROTRAC: A SINGLE-SOURCE SOLUTION PROVIDER FOR PARTICLE CHARACTERIZATION

PARTICLE SIZE & SHAPE FOR PARTICLE ANALYSIS

Size & Distribution

Shape

Our expertise in particle size distribution and shape analysis ensures optimal product quality control and supports advanced research efforts. At the core of our technology are **Dynamic Image Analysis (DIA) used on the Camsizer** and a combination of **Laser Diffraction (LD) and Dynamic Image Analysis used on the SYNC** systems. These two technologies cover all your needs for particle size analysis, ranging from 10 nm to 135 mm, whether for dry or wet samples. Our unique size & shape analysis technology utilizes advanced light scattering, state-of-the-art cameras, and sophisticated computational software to deliver outstanding accuracy and repeatability.

COLLOIDS AND FORMULATIONS CHARACTERIZATION

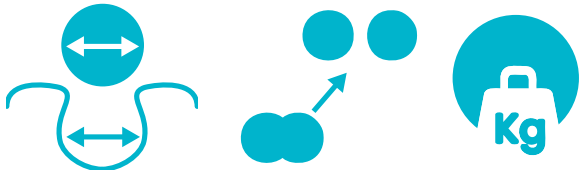
Particle size

Zeta potential

Stability & Shelf-Life

When working with colloids or formulations, the three main parameters to consider are **particle size, zeta potential and stability/shelf-life.** At Microtrac, we address all these needs with our comprehensive technology platforms: **NANOTRAC, STABINO, and TURBISCAN**. Our solutions analyze these critical factors to ensure rapid R&D and quality control for the highest product quality. Utilizing **Dynamic Light Scattering (DLS), Static Multiple Light Scattering (SMLS), and Zeta Potential (ZP),** our systems offer unique features such as non-dilution, high accuracy, and fast measurement—enabling you to make fast decisions based on reliable data.

GAS ADSORPTION FOR MATERIALS CHARACTERIZATION



Surface Area & Pore size

Catalysis

Density

We offer advanced solutions for measuring surface area, porosity, and catalytic properties of materials. The MICROTRAC analyzers, celebrated for their precision in **gas and vapor adsorption measurements,** determine BET surface area and pore size distribution for both porous and non-porous materials. These analyzers employ cutting-edge gas adsorption technology and are widely used in various sectors, including Research and Development, Quality Control, and Quality Assurance. These tools are trusted worldwide, reflecting the renowned craftsmanship and quality of Japanese engineering, with comprehensive support provided by our competence centers in Japan (Osaka), Germany (Haan), USA (Newtown, PA) and France (TOULOUSE). The **BELSORP** and **BELPORE** analyzers are essential for achieving accurate gas and vapor adsorption analysis.

BELSORP MAX X

HIGHLY ACCURATE GAS & VAPOR ADSORPTION

- Smallest footprint: more compact design, lower weight
- Highly reproducible BET specific surface area and pore size distribution evaluation
- Highest throughput with simultaneous measurement of up to 4 samples
- Advanced Free Space Measurement: AFSM™ and AFSM2™ (Helium-free)
- Low specific surface area evaluation by Kr adsorption at 77.4 K
- Evaluation of hydrophilic and hydrophobic material
- Adsorption rate measurement for various gases and vapors
- Supports a wide range of gas / vapor adsorbates and measurement conditions
- Chemisorption option
- Measures various materials such as molded bodies, pellets, and fine powders

The BELSORP MAX X is a versatile instrument that measures specific surface area, pore size distribution, vapor adsorption, and chemisorption. The instrument allows for comprehensive surface characterization, such as BET surface area and micropore analysis, by measuring the adsorption isotherms from extremely low pressures, organic vapor sorption or hydrophilicity / hydrophobicity characterization through water vapor adsorption.

These capabilities are accomplished by the proprietary technical advantages of heated manifold blocks (50 °C, opt. version BELSORP MAX HT 80 °C) for a constant ambient temperature, heated air bath, and electropolished manifold lines to avoid surface wetting and corrosion. Furthermore, the BELSORP MAX X features pneumatic valves to minimize leakages or outgassing when working with high vacuum.

The BELSORP MAX X not only supports a wide range of gas and vapor adsorbates, but various measurement conditions as well. In addition, the special version BELSORP MAX X HP can measure isotherms up to 0.9 MPa

BELSORP MAX X Features

- **Specific surface area range:**
  - 0.01 m^2/g or more (N_2)
  - 0.0005 m^2/g or more (Kr)
- **Pore size distribution range:**
  - 0.35 to 500 nm
- **Highly accurate vapor adsorption measurement under strict temperature control**
- **Advanced GCMC / NLDFT method offers higher resolution & more precise PSD analysis**
- **IoT: Measurement status & results remotely via e-mail system**

BELSORP MAX X

BELCONTROL OPERATION SOFTWARE

The software has given the highest priority to simplify the operation and has been equipped with many functions to increase the labor productivity. Since the BELSORP instruments offer many features and possibilities, it gets more and more important to simplify the use. Our software will guide you step-by-step for the implementation of several procedures e.g. execution of measurements, replacement of gas cylinder, purging of the manifold and degassing of liquid adsorptive. This user-friendly feature is making the instrument accessible even for non-experienced users.

For the isotherm measurement conditions two possibilities are offered depending on the level of user-experience.

Firstly, the 'automated setting' enables an easy operation by entering the sample information, selecting pretreatment conditions (skippable if externally done) and measurement points/ range. Therefore, it is ideal for measurement of unknown samples or unexperienced users. If a prior measurement with comparable sorption behavior is available, the GDO function can be used to reduce the measurement time.

Secondly, the 'advanced setting' offers detailed configuration possibilities for control of dosing amounts and equilibrium criteria to optimize measurement conditions manually. The e-mail notification automatically sends the measure-ment status and results as an e-mail. With this function easy and reliable monitoring will be given. Our instruments are equipped with a diagnostic service tool, the so-called System Check. It enables functionality proof of the main parts and the equipment status. The System Check result is saved as a report, summarizing the leakage rates, functionality of single parts.

I Control up to 5 units / 20 measurement ports with a single PC

Software Features

- **Microtrac's measurement operation software features a uniform user experience and can be used with BELSORP MINI X, MAX G, and MAX X**
- **The software offers automated and manual settings so that optimization can be made based on user experience**
- **Three sub modes are available:**
  - I High-precision mode for R&D
  - I Multi-sample mode for high throughput
  - I Quick BET mode for QC

High Precision Mode

For high-precision measurements the amount of free space change in the sample section is simultaneously measured at the reference port (AFSM™). The other remaining ports are used for measuring the adsorption / desorption isotherms, while the saturated vapor pressure is constantly monitored with a dedicated port.

I Resolution: 0.01 m^2

I Reproducibility:

Total surface area 1 m^2 → ± 1.2%*

Total surface area 10 m^2 → ± 0.4%

Multi-Sample Mode

This mode allows for measuring adsorption and desorption isotherms with up to four samples, while the saturation vapor pressure is constantly measured at the dedicated port. The free space change can be automatically calculated from the prior saved free space file *(dvd)*.

I Resolution: 0.01 m^2

I Reproducibility:

Total surface area 10 m^2 → ± 0.5%

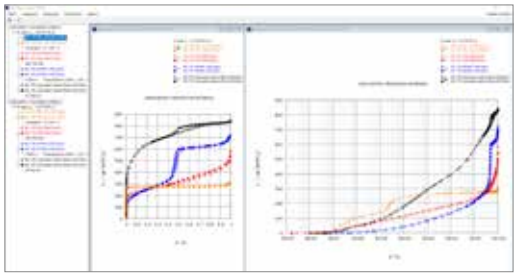
Quick BET Mode

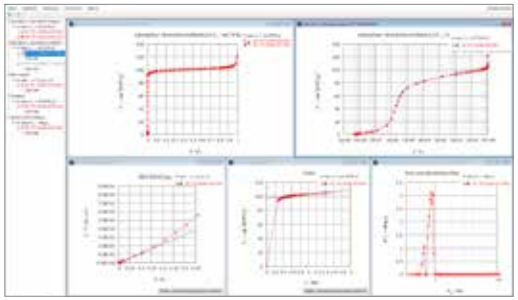
The quick BET mode can be used to maximize the sample throughput. In this mode it is possible to measure three BET adsorption points for four samples in approx. 15 minutes.

* The total surface area (m^2) is the product of both the specific surface area (m^2/g) and the sample mass.

BELSORP MAX X

BELMASTER EVALUATION SOFTWARE





Software Features

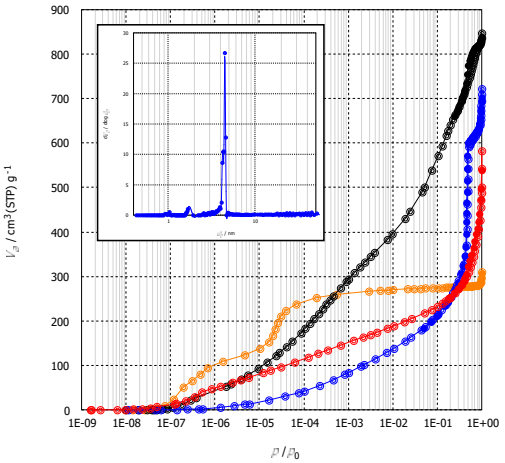
- Analysis data and results can be saved by Drag & Drop (MS Excel format)
- Easy change of chart overwriting, X-Y axis scaling, unit conversion, and more
- Result window can be saved for further analysis after a computer restart
- Routine analysis setting function (useful for repeated analyses)
- Customized data can be registered as standard reference isotherms in pore profile analyses, t-plot and αs
- Improved visibility for different analyses through individual color setting for custom data

The evaluation software BELMASTER offers a wide range of both basic and advanced analytical theories which have been developed over many years of experience and provides the widest characterization of the samples:

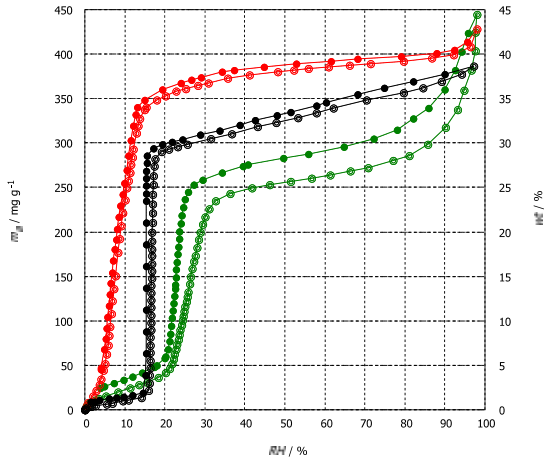
- Adsorption-desorption isotherm / PCT curve
- BET Specific Surface Area, incl. ISO9277 / Rouquerol plot for Type I isotherms
- Langmuir & Freundlich specific surface area
- INNES, BJH DH & CI method (mesopores)
- HK, SF & CY method (micropore distribution, only for BELSORP MAX series)
- t-plot method (micro to mesopore analysis)
- αs plot method (micro to mesopore analysis)
- MP method (micropore distribution)
- Dubinin-Astakhov & Dubinin-Radushkevich method (micropore volume)
- Isosteric heat of adsorption (for MAX series)
- Differential adsorption isotherm
- Fractal dimension
- Molecular Probe Method (ultra micropore)
- Adsorption rate analysis & Metal dispersion
- BELSim™: NLDFT / GCMC (ISO15901-2) for micro- to- macropore distribution

MEASUREMENT RESULTS

BELSORP MAX X

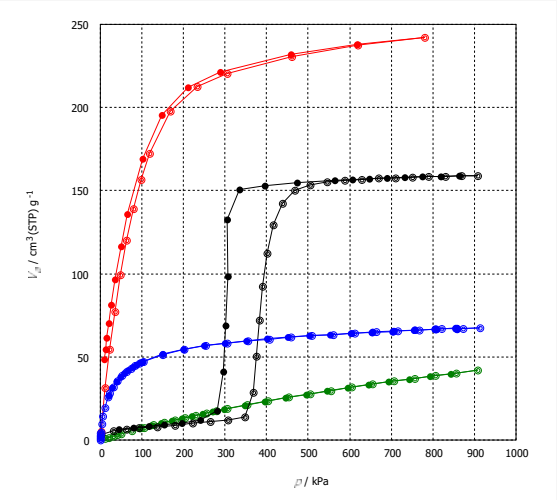


Nitrogen sorption measurements of micro-/mesoporous materials: metal-organic framework MIL-160 (orange), Pd-Carbon (red), activated carbon fibre (black) and MCM-41 (blue) at 77.4 K. Top, left: Exemplary GCMC pore size distributions of MCM-41 (blue) based on nitrogen adsorption isotherms at 77.4 K.

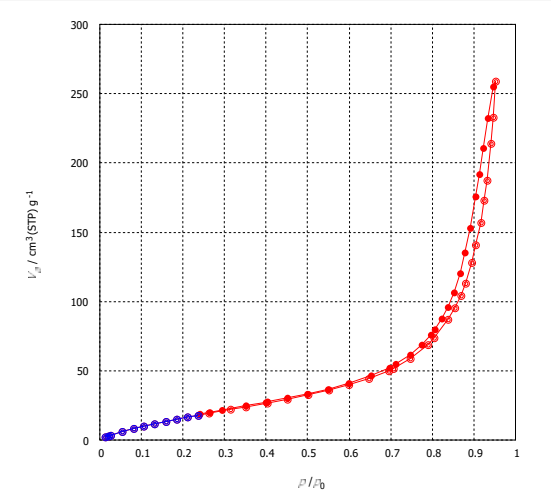


Water sorption measurements of the three metal-organic frameworks (MOFs): Aluminum-fumarate (green), MIL-160 (red) and CAU-10H (black) at 25 °C.

Microtrac provides evaluation methods which cover a wide range of pore sizes and various adsorbates, such as N_2 (77.4 K), Ar (87.3 K), and CO_2 (298 K). It uses NLDFT / GCMC kernels of slit, cylinder, and cage pore models with carbon and metal oxide surface atoms, resulting in the most appropiate description of porous materials. Our BELMASTER software (Ver. 7) allows for the easy comparison between experimental and simulated isotherms, with the simulated isotherm serving as a basis for the PSD calculation. The similarity between them is an indicator for the correct PSD calculation.



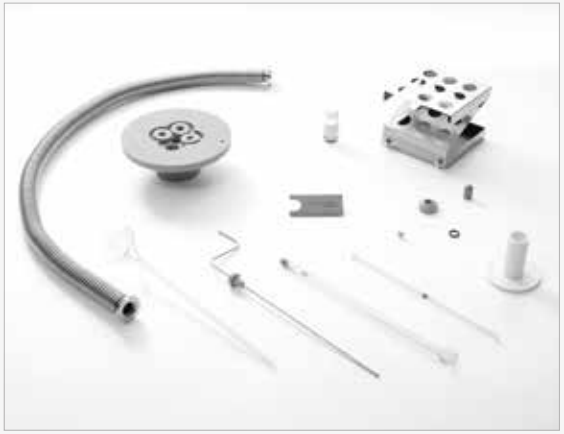
High pressure gas sorption isotherms of ZSM-5 CO_2 at 20 °C (blue), Activated Carbon N_2 at 25 °C (green), LaNi5 H2 at 25 °C (black) and Kuractive NH_3 at 25 °C (red) on BELSORP MAX X HP model.



High temperature water sorption isotherms of Aerosil at 70 °C on BELSORP MAX X (blue) and BELSORP MAX X HT model (red) incl. measurable relative pressure ranges (table).

BELSORP MAX X

FURTHER OPTIONS & ACCESSORIES



STANDARD CONSUMABLE GOODS

- Sample cells, filler rods, filters, O-rings, caps & weighing platforms, NSD capsules, liquid bottles, various sizes of sample cells, quick seals, and much more.

GAS SELECTORS

- Up to 12 gases can be mounted with external gas selectors to accommodate different types of adsorbates.

HEATER & CONTROLLER

- Pretreatment of the sample from 50°C up to 550°C.

WATER BATH

- Water bath for measurement temperature ranging from -10°C to 80°C. A refrigerated / heated circulator is required for usage.

ACCESSORIES FOR VAPOR SORPTION

- Our accessories for vapor sorption include a detachable airbath, glas vessel for liquids, a reference sample for vapor sorption, and a Dewar for the degassing of liquids.

TECHNICAL DETAILS

SPECIFICATIONS AT A GLANCE

System		BELSORP MAX X	BELSORP MAX X HP	BELSORP MAX X HT
Measurement principle		Volumetric / manometric method + AFSM™ (Advanced Free Space Measurement)		
Adsorption gas		N_2, Ar, Kr, CO_2, H_2, O_2, CH_4, NH_3, NO, CO, butane, and various other non-corrosive gases		
Adsorption vapor		H_2O, MeOH, EtOH, C_6H_6, CCl_4, hexane, and various other (non-)corrosive vapors		
Number of measurements (high accuracy mode)		Max. 4 ports simultaneously (3)	Max. 3 ports simultaneously (2), 1 port for high pressure	Max. 4 ports simultaneously (3)
	Specific surface area	~0.01 m^2/g (N_2), ~0.0005m^2/g (Kr) (depending on sample density)		
	Pore size distribution (⌀)	0.35~500 nm (from ~0.25 nm when CO_2 is used)		
	Low pressure isotherm	P/P_0 = ~10^{-9} (N_2 @ 77K, Ar @ 87K)		
	Vapor adsorption	P/P_0 = ~0.95 @ 40°C		P/P_0 = ~0.95 @ 70°C
	High pressure	-	10 Pa ~ 900 kPa	-
Pressure transducer	1 MPa (7500 Torr)	-	1	-
	133 kPa (1000 Torr)	6	5	6
	1.33 kPa (10 Torr)	4 (max.)	3	4
	0.0133 kPa (0.1 Torr)	3 (max.)	2	-
Thermostatic air oven		50°C		80°C
Gas ports		3 ports* (optional 6, 9 or 12 ports max.)	3 ports* (optional 6, 9 or 12 ports max.)	
CE certificate		✓		

* Corrosion-resitant

07/2023 Subject to technical modifications and errors

System	Pore size distribution	Micropore	Mesopore	Macropore	Isotherm	Single point BET	Multi point BET	Vapor adsorption	Chemisorption (static volumetric)	True density
BELSORP MAX X	⊕	⊕	⊕	+	⊕	⊕	⊕	⊕	+	+

⊕ *suitable* + *suitable to a limited extent* - *not suitable*

MICROTRAC
PARTICLE CHARACTERIZATION

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VERDER

ENABLING PROGRESS

Verder Scientific is composed of leading laboratory equipment companies active in sample preparation and analysis for quality control as well as research & development purposes.

As trusted solution partner, Verder Scientific enables thousands of companies to ensure economic, technological and environmental progress by mastering their scientific applications. Together, we make the world a healthier, safer and more sustainable place.

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