MICROTRAC
a VERDER company

BET SPECIFIC SURFACE AREA & PORE SIZE ANALYZER

BELSORP MAX G

Quick, Easy Characterization of Powder Materials with the Highest Accuracy

The BELSORP MAX G is a powerful, compact, and economical model in Microtrac's BELSORP MAX series of BET specific surface area and pore size analyzers. It allows the measurement of gas adsorption isotherms starting from extremely low pressures for the evaluation of micro-, meso- and macroporous materials, as well as non-porous materials.

The analyzer is equipped with one measurement port, one dedicated port for saturated vapor pressure measurement, and one port for free space (dead volume) analysis. Each port is equipped with a dedicated pressure sensor for high-precision analyses.

The BELSORP MAX G surface area & pore size distribution analyzer is capable of analyzing a wide range of materials, including pellets, molded bodies, substrates, and finely dispersed samples thanks to specially designed sample tubes.

The unit also supports a wide range of adsorbates and measurement conditions. The instrument is available in two different versions, making it suitable for a wide range of applications: BELSORP MAX G LP (Low Pressure) and BELSORP MAX G MP (Medium Pressure). Either version is equipped with a specific pressure transducer to best suit your needs.

	BELSORP MAX G LP	BELSORP MAX G MP
Port 1	1,000 Torr, +10 Torr, +0.1 Torr	1,000 Torr, +10 Torr, +1 Torr
Port 2	1,000 Torr	
Saturation vapor pressure port	1,000 Torr	
Turbomolecular pump	yes	

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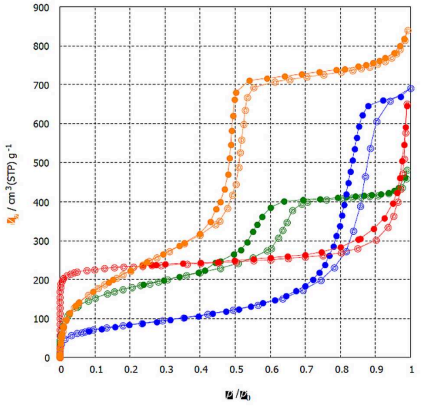
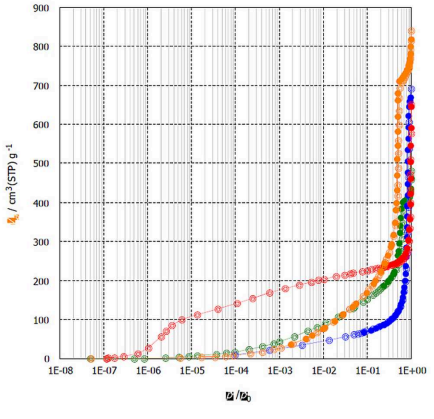
KEY FEATURES

Ultra-Low Pressure Measurement

The BELSORP MAX G allows for high-accuracy measurement of adsorption isotherms in a wide range, starting from the ultra-low pressure region ($P/P_0 = 10^{-8}$, N_2 @ 77 K) to atmospheric pressure. The BET surface area and pore size distribution analyzer includes a turbo molecular vacuum pump and low-voltage pressure transducer.





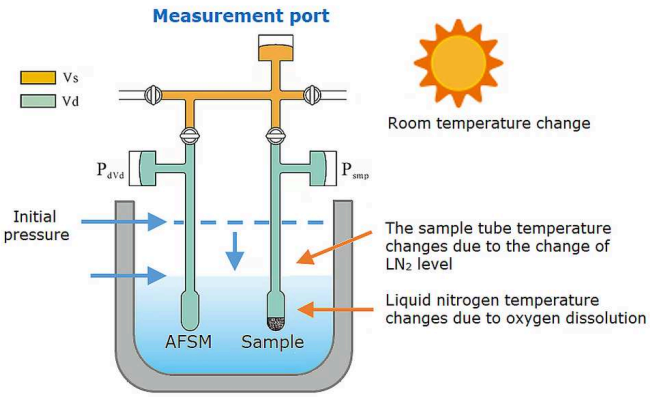
Innovative Free Space Measurement for Highest Accuracy (AFSM^{TM})

Strictly controlling the level of liquid coolants (e.g. liquid nitrogen or argon) is no longer required with the BELSORP MAX G. Instead, we have implemented our groundbreaking, continuous free space measurement method: the patented Advanced Free Space Measurement (AFSM^{TM}). This method achieves the highest level of reproducibility by using a reference cell to follow the second-to-second changes of free space. First, the instrument determines the free space of the sample cell and reference cell. Then, as the analysis proceeds any changes to the system that might alter the measured Free Space are concurrent in both cells. Therefore, alterations in the measured free space can be continuously accounted for through the reference cell.

Examples of causes for free space fluctuations include:

- Liquid nitrogen (LN_2) level changes
- Atmospheric temperature and pressure changes
- Coolant temperature changes due to dissolution of oxygen

With this superior technique, environmental factors can be taken into account that were not considered before. For more information, please visit our knowledge base.

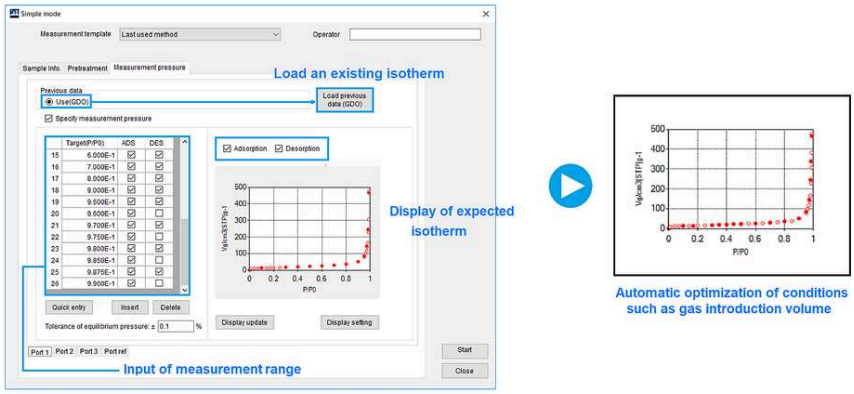


Ease of use – Simple Setting of Measurement Conditions

The BELSORP MAX G has a fully automated system that enables the user to easily setup measurement conditions through ‘Simple Mode’. This mode makes sample analysis a breeze by only requiring minimal user entry (e.g., sample information, pretreatment conditions and measurement range). This is particularly useful for unknown materials and for the application of standard operation procedures. Detailed measurement configurations can be set by experienced users by selecting the ‘Professional Mode’.

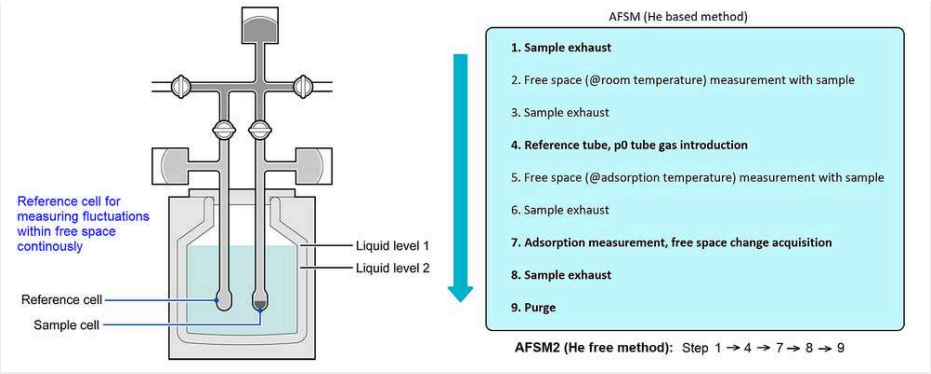
Gas Dosing Optimization (GDO)

The Gas Dosing Optimization (GDO) function calculates the optimal gas dosing amount from previous measurement results. This function can reduce measurement times significantly.



Helium-Free Measurements (AFSM™2)

By measuring the free space of a 'blank' sample tube in advance, measurements can be achieved without the need for helium gas. Using the same sample tube, in the same analysis conditions, the free space can be easily calculated using your sample's mass and density. This method also reduces sample analysis time by cutting out the free space determination at the beginning of every sample measurement. With AFSM™2, there is no need to match the liquid level of the coolant between the blank measurement and sample analysis.



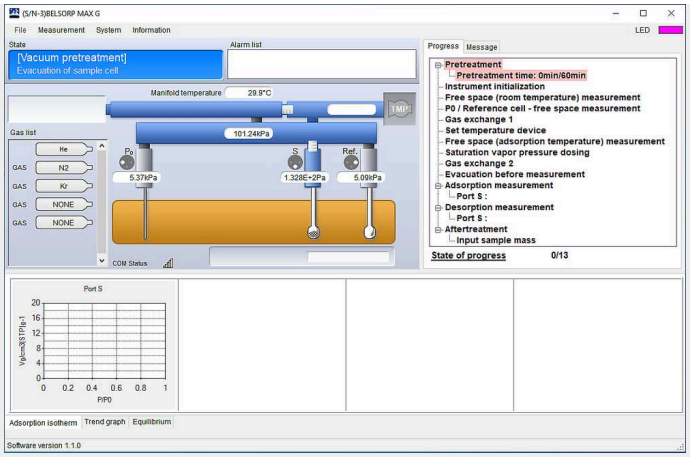
Compact & Lightweight

By optimizing the component materials, we have managed to provide a unit with a small footprint and low weight.

In-Situ Pretreatment (Optional)

For an accurate adsorption measurement, a pretreatment of the samples is required. The pretreatment process (also called activation process) is usually performed by applying vacuum under heat, which removes adsorbed gas and / or water molecules from the surface of the material without affecting the sample structure (avoiding denaturation).

Microtrac offers two options for sample pretreatment. First, it can be performed externally using our BELPREP equipment, which is usually preferred to increase sample throughput. Alternatively, the activation process can be performed directly at the measurement port of the BELSORP MAX G using a heater (see accessories list). This way, a transfer from the external pretreatment device to the measuring port can be avoided, which is an important option for sensitive samples (e.g. hydrophilic material).



Data Analysis

Our BELMASTER analysis software is provided with the BELSORP MAX G, and enables the user to perform a wide variety of data analysis, including evaluating specific surface areas using the Langmuir or BET method, evaluating pore volumes by applying the t-plot method, conducting mesopore analyses with the DH or BJH method, micropore analyses via HK or SF method, or GCMC / NLDFT analyses, and much more.

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ACCESSORIES AND OPTIONS

STANDARD CONSUMABLE GOODS

Our standard consumables consist of sample cells, filler rods, filters, O-rings, caps and weighing platforms that are required for adsorption measurements. NSD capsules, a variety of sample cells, quick seals, and much more are part of the consumable goods.

WATER BATH

Easily swap the Dewar with a water bath for measurement temperatures ranging from -10°C to 70°C. A refrigerated / heated circulator is required.

HEATER

In-situ pretreatment of the sample from 50°C to 450°C. With this option, samples can be pretreated directly at the measurement port, without the need to transfer the sample cell before analysis. Particularly useful for sensitive samples.

GAS SELECTOR

The gas selector enables the connection of up to 4 adsorptives simultaneously (1 x Helium + 4 x adsorptive).

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BELCONTROL: NEW OPERATION SOFTWARE

The versatility of BELSORP equipment is truly world leading. The numerous features and capabilities are complemented by BELCONTROL the intuitive and user-friendly operation software. It guides the user step-by-step through the analysis process. This includes the setup of analysis conditions, executing the measurements, when to fill and setup the liquid nitrogen or other bath, when to replace the gas cylinder, the degassing steps, and much more. The software is designed to make the instrument accessible and operable to everyone, including inexperienced users.

For inexperienced users or for measurements of unknown samples, BELCONTROL only requires basic sample information (name, mass, etc.), pre-treatment conditions (if not performed externally) and the measurement range.

Detailed control of the configuration and measurement settings is possible to optimize the measurement conditions (e.g. dosing settings, equilibrium criteria, leak test option, etc.). This allows the user to fully customize the sample analysis to his needs.

	BELCONTROL	
Quick BET	yes	Multi-point BET surface area in less than 20 minutes
Helium-Free Measurement	yes	AFSM^{TM} 2 enables He-free measurements with unmatched accuracy
Adsorption Kinetics	optional	Rate of adsorption measurements for diffusion analysis

MORE BELCONTROL FEATURES

- Overlaying adsorption / desorption isotherms and comparing the measured data between the various ports during measurement
- All pressures, temperatures, valve actuations, etc. are stored in trend data, allowing for immediate examination
- A system check function is available for

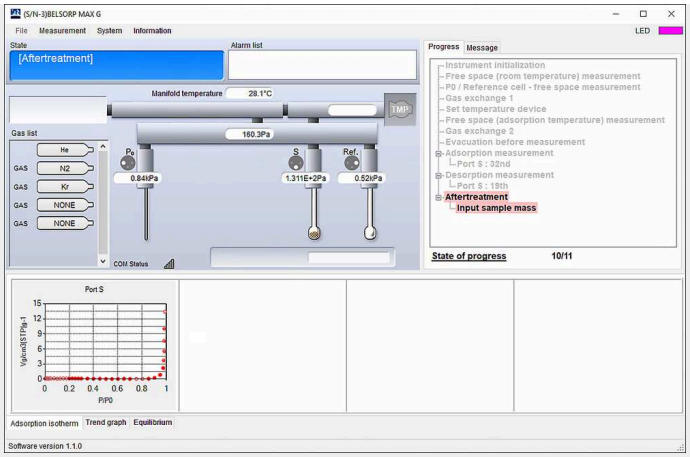
- diagnosing the instrument status
- E-mail notification automatically transmits measurement status and results
- Interactive program in Japanese or English ensures easy, reliable operation
- Extensive help functions, including step-by-step instructions during operation

BET SPECIFIC SURFACE AREA & PORE SIZE ANALYZER BELSORP MAX G

OPERATION SOFTWARE

The versatility of the BELSORP instruments, with their many features and possibilities, is complemented by our intuitive and user-friendly operation software. It guides the user step-by-step through the analysis process including setting up the analysis conditions, executing the measurements, when to fill and setup the liquid nitrogen or other bath, when to replace the gas cylinder, the degassing steps, and much more. The software has been crafted to make the instrument accessible to everyone, even inexperienced users.

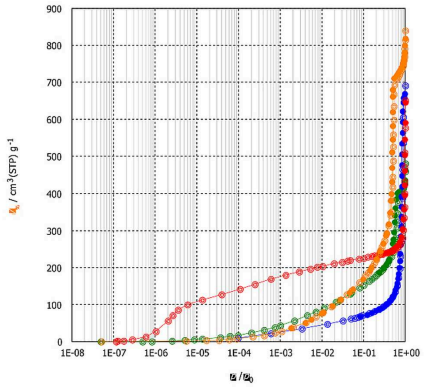
Two measurement modes are offered: ‘Simple Mode’ and ‘Professional Mode’. Simple Mode enables easy operation, requiring minimal setup. You only need to enter the basic sample information (name, mass, etc.) and then select your pretreatment conditions and analysis conditions from a list of preset options. This is ideal for inexperienced users or measurements of unknown samples. If a prior measurement with comparable sorption behavior has been performed, GDO can be used to reduce the measurement time. Professional Mode allows detailed control of the configuration and measurement settings (e.g., dosing settings, equilibrium criteria, leak-check option, etc.), allowing the user to completely customize sample analysis.

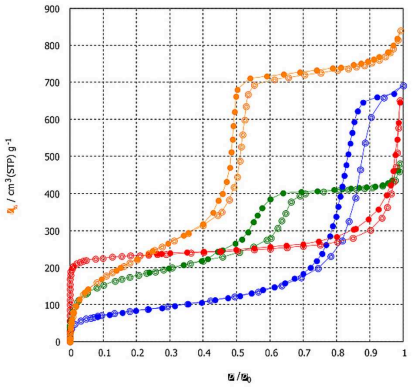


GAS ADSORPTION MEASUREMENTS OF POROUS & NON-POROUS MATERIALS: MOFS, ZEOLITES, CARBONS, AND MORE

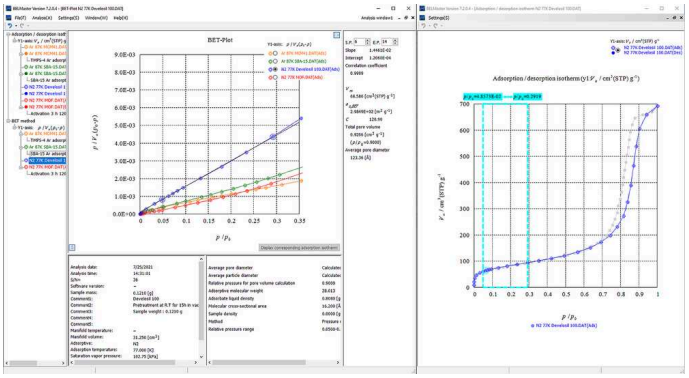
EVALUATION SOFTWARE BELMASTER

A sorption isotherm is defined as the relationship between the adsorbed amount onto an adsorbent and the equilibrium pressure of the adsorptive gas – commonly related to the saturation vapor pressure – at constant temperature. The gas sorption isotherm (e.g. nitrogen) delivers information about the specific surface area, pore size distribution and pore volume of measured material. In the following graph some exemplary sorption isotherms are shown.





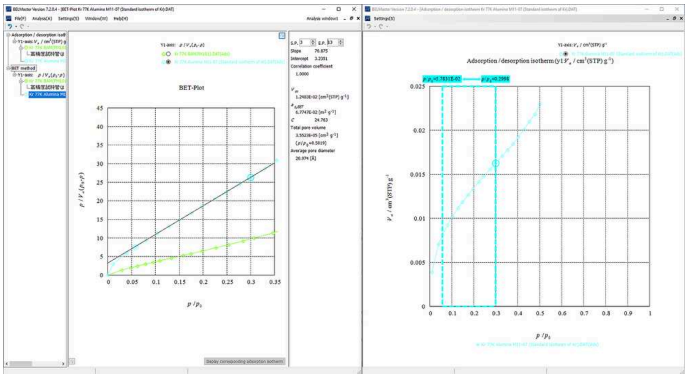
The specific surface area (SSA) refers to the accessible surface area of the sample and is of great importance in adsorption, homogeneous and heterogeneous catalytic reactions. The specific surface area can be calculated according to ISO 9277 with the BET method (BET: Brunauer, Emmett and Teller) or Langmuir method. The following graph shows an exemplary evaluation of the specific surface area according to the BET method in our BELMASTER software:



Select the right pressure range (multi point BET) or a measurement point (single point BET) and the surface area will be calculated automatically. Further, our BELMASTER software also provides the BET surface area calculation according to ISO 9277 Annex C (also known as Rouquerol-plot), which is recommended for microporous materials.

The outstanding feature of the BELSORP MAX G is the availability of three different transducers (1000, 10 and 1 / 0.1 torr), enabling very low pressure adsorption isotherms, starting from $p/p_0 = 10^{-8}$ (N_2 @ 77K) up to atmospheric pressure. As a result, pore size distributions from 0.35 up to 500 nm can be obtained. Further, low surface area measurements down to 0.0005 m^2/g by using krypton gas are possible.

The characterization of low specific surface area materials such as non-porous metallic materials, glass substrates, and films can be difficult or impossible with traditional gases like nitrogen (77 K) and argon (77 K or 87 K) due to detection limits. Instead, krypton gas adsorption can be used at liquid nitrogen temperature to determine the BET specific surface area down to 0.0005 m^2/g.



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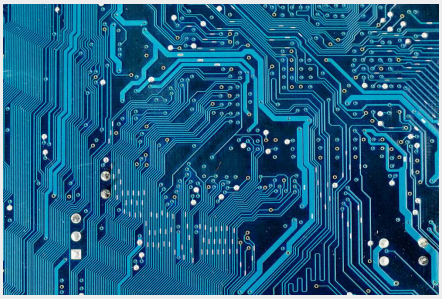
TYPICAL APPLICATIONS

Microtrac's gas adsorption analyzers are used in a variety of fields. These include catalysts, batteries, fibers, polymer materials, zeolite, fuel cells, chemicals, pigments, cosmetics, MOF / PCP, magnetic powders, separation membranes, filters, toners, cement, ceramics, semi-conductors, and many more.

- battery materials
- catalysts
- zeolite
- ceramics
- carbon



- electronic components
- fuel cells
- Toner particles
- cement
- medicine / pharmaceuticals

- silica
- MOF / PCP
- pigments
- cosmetics

... and many more!

To find the best solution for your particle characterization needs, visit our application database

BET SPECIFIC SURFACE AREA & PORE SIZE ANALYZER BELSORP MAX G

TECHNICAL DATA

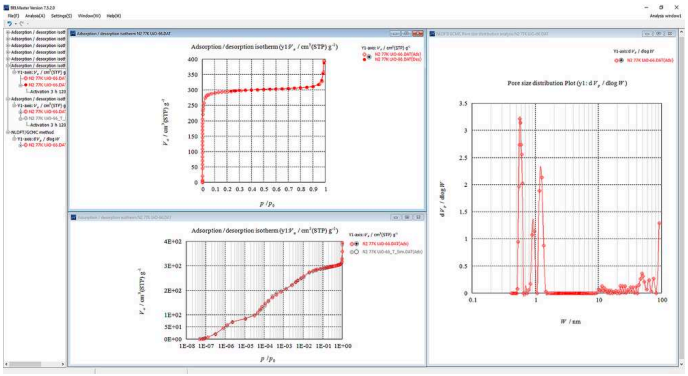
Measurement principle	Volumetric method + AFSM™
Adsorption gas	N2, Ar, Kr, CO2, H2, O2, CH4, NH3, NO, CO, butane, and various other (non-)corrosive gases
Gas ports	2 ports (5 ports max.)
Number of measurements (High Accuracy mode)	1 port in High Accuracy mode
Measurement range (specific surface)	0.01 m^2/g and above (N_2) 0.0005 m^2/g and above (Kr) (depending on sample density)
Pore size distribution (Diameter)	0.35 - 500 nm
Low pressure isotherm	$p/p_0 = 10^{-8}$ (N_2 @77K, Ar @87K)
Pressure transducer	133 kPa (1000 Torr) x 3 units 1.33 kPa (10 Torr) x 1 unit 0.133 kPa (MP) or 0.0133 kPa (LP) x 1 unit
Vacuum gage / pump	Turbo molecular pump + rotary pump Cold cathode gauge (optional)
Sample tube	Standard tube, approx. 1.8 cm3 (optional: 5 cm3)
Dewar vessel	Volume: 2.6 L Holding time: 80 h
Pretreatment heater	50 - 450 °C
Water bath	-10 - 70 °C
Analysis software BELMaster™ 7	Adsorption isotherm, BET specific surface area I type (ISO9277), BET automatic analysis, Langmuir specific surface area, BJH, DH, CI, INNES method, t-plot, Alpha-s plot
Analysis software BELMaster™ 7 cont.	HK, SF, CY method, NLDFT / GCMC, MP method, Dubinin-Astakhov method, Difference adsorption isotherm, Molecular probe, Adsorption rate analysis (opt.)
Dimensions (W x H x D)	320 x 740 x 465 mm
Weight (main body)	36 kg
Utility - Gas	He, adsorption gas: 0.1MPa (G), purity: more than 99.999% Joint: 1/8" Swagelok joint
Utility - Power	Main unit: AC 100 - 240 V / 850 W, 50 / 60 Hz (including vacuum pump)

Environmental conditions	Temperature: 10 - 30 °C Humidity: 20 - 80% RH
ASTM compliance	B922, C110, C1069, C1240, C1274, D1993, D3663-20, D3908, D4222, D4365, D4641, D4780, D4842, D5604-96, D6556, D8325, E2864, WK61828, WK71859
Standards	4652, 8008, 9277, 12800, 15901-2, 15901-3, 18757, 18852
USP compliance	268, 846
DIN compliance	66134 (1998-02), 66135-1 (2001-06), 66135-2 (2001-06), 66135-3 (2001-06), 66135-4 (2004-09)
CE certified	yes
Recommended Monitor	Full HD monitors

FUNCTIONAL PRINCIPLE

Analysis of Pore Size Distribution via NLDFT & GCMC Method

The classical pore size distributions (PSD) are calculated by INNES method (slit shape) and BJH, DH, CI methods (cylinder shape), which evaluate mesopores based on the capillary condensation theory. HK (slit), SF (cylinder), and CY (cage) methods can also be used to evaluate micropores based on the adsorption potential theory. The DA method, as well as the DR method, are also commonly used for pore volume evaluation and pore structure evaluation. The new PSD and capacity evaluation methods, NLDFT and GCMC (optional for BELSORP MINI X), are used for wide range analyses (from micro- to meso and macropores) and more accurate methods, specified in ISO15901-2.



Theory	Interaction Surface and Gas	Adsorbate	Applicable Pore Size Range
BJH, CI, DH, INNES method	Kelvin equation (Surface tension and contact angle)	Bulk liquid density	> 2 nm Meso and macropore
HK, SF, CY method	Lennard-Jones potential (Interaction and repulsion force)	Bulk liquid density	0.4 - 2 nm Micropore
NLDFT, GCMC	Statistical thermodynamic model		0.35 - 500 nm Whole pore range

In recent years, attention has been focused on pore structure evaluation methods using computer simulations, such as the novel pore distribution analysis NLDFT (Non-localized Density Functional Theory) and GCMC (Grand Canonical Monte Carlo) method, which can analyze micropores to meso- and macropores using a unified theory. Pore size distributions obtained from the same adsorption isotherm are different between classical and novel PSD analyses, and even in between novel methods because the filling pressure obtained from each theory is different. 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 appropriate description of porous materials.

The BELMASTER software allows easy comparison between experimental and simulated isotherms, with the simulated isotherm serving as a basis for the PSD calculation.

www.microtrac.com/belsorp-max-g