



CATALYST ANALYZER

BELCAT II

www.microtrac.com/products/gas-adsorption-measurement/catalyst-evaluation/belcat-ii/

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CATALYST ANALYZER

Unlock state-of-the-art catalyst characterization with the BELCAT II. The performance of solid catalysts is shaped by specific surface properties, with factors like nature and distribution of active sites, acidity, basicity, redox behavior, electronic structure, and surface morphology all playing critical roles in determining catalytic activity, selectivity, and stability.

The BELCAT II delivers precise analysis of metal dispersion rates, metal surface areas, and average particle size for supported precious metal catalysts, helping researchers enhance catalyst performance while reducing costs.

In addition to providing measurements of specific surface areas (BET) and adsorption kinetics, the BELCAT II determines adsorption capacity through breakthrough curve analyses. These data are essential for the development of innovative adsorbent materials.

As a comprehensive catalyst analyzer, it combines all functions in a single device, offering broad applicability and extensive customization to support diverse research and development objectives.



ALL-IN-ONE, FULLY AUTOMATIC AND MULTI-PURPOSE ANALYZER

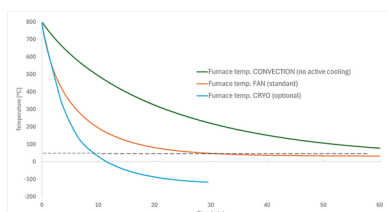
WHY BELCAT II?

Discover the standout capabilities of the BELCAT II instrument. Below is a list of its key features, designed to provide comprehensive and reliable catalyst analysis while offering flexibility to suit diverse research and development requirements.

MULTI-PURPOSE GAS DOSING DESIGN

The integrated multiline gas manifold allows simultaneous connection of up to eight different gases – including two corrosive types – which are internally distributed throughout the system. This smart design supports software-controlled blending, enabling precise generation of customized gas mixtures directly within the unit. These blends can be used during sample pretreatment, analysis, pulse loop operations, and automated calibration. By eliminating the need for premixed gases and minimizing external tubing, the system enhances workflow efficiency, reduces operating costs, and significantly lowers the risk of leakage.

	BELCAT II (multi-purpose)	Alternative devices (single-purpose)
Preparation gases	1. He, 2. N ₂ , 3. Ar, 4. H ₂	5 gas lines: 1. He, 2. N ₂ , 3. O ₂ / He, 4. H ₂ / Ar, 5. CO / He
Analysis (loop) gases	5. CO, 6. O ₂ , 7. N ₂ O, 8. NH ₃	5 gas lines: 1. H ₂ , 2. CO, 3. NH ₃ / He, 4. O ₂ , 5. N ₂ O
Carrier gases	1. He, 2. N ₂ , 3. Ar	3 gas lines: 1. He, 2. N ₂ , 3. Ar
Total	8 gas lines needed to prepare the same gas(-mixtures)	13 gas lines are needed



SUPERIOR TEMPERATURE CONTROL

Heating rates reach up to 110 °C/min from 50 to 500 °C, or 80 °C/min from 50 to 1000 °C, with a maximum operating temperature of 1100 °C. Fan-assisted cooling reduces the temperature from 400 to 50 °C in 30 minutes. The CATCryo II option cools down to -120 °C and from 800 to 30 °C in 10 minutes.

DESIGNED FOR RESEARCH



Features an auto-locking safety-door, overheat protection, automatic shutdown, integrated alarms, and optional gas detection for the highest level of operational safety. The supplied zeolite trap – to remove moisture during TPR experiments – eliminates the need for liquid nitrogen.



State-of-the-art design ensures efficient gas preheating and maximizes throughput for demanding workflows. The cylindrical design of the tube enhances ease of handling and increases safety by being tension-free and less prone to breakage.



Its expandable architecture supports seamless integration of a vapor dosing unit, external gas mixing module, and a cryogenic option for enhanced adsorption studies and accelerated cooling.



Sequential measurement mode allows for seamless combination of thermochemical methods and catalyst testing steps in a single workflow.



Designed specifically for pulse chemisorption analysis and temperature programmed methods, with minimized dead volume, a temperature-controlled high-performance thermal conductivity detector (TCD), and advanced circuitry.

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OPTIONS

Extend catalyst characterization with optional vapor dosing, external gas mixing, cryogenic cooling, online gas analysis, air-protected sample handling, and mixed-gas breakthrough measurements.



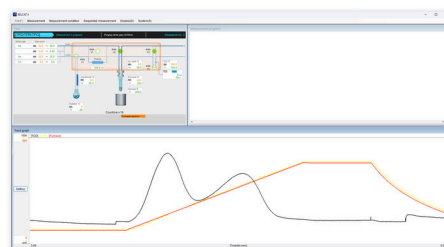
Vapor dosing unit	Consists of an air thermostat unit, bubbler, heater and condenser. The condenser eliminates excess vapor. Two-stage process ensures precise vapor dosing at stable concentrations.
External gas mixing unit	Allows mixing of three or more gases. One unit can install up to six lines. Corrosive gases are supported.
Low temperature electric furnace / CATCryo II	By applying the liquid nitrogen spray, the sample temperature can be continuously controlled from -120 °C. The cooling performance is improved with the optimal internal structure, and the liquid nitrogen consumption is drastically reduced.
On-line gas analyzer / BELMASS II	Systemized quadrupole mass spectrometer, BELMASS II can be connected with BELCAT II. Multiple components of gases can be measured at high quantitative accuracy while linked with the BELCAT II software. Ideal for demanding experiments, including catalytic reactions.
AIRGUARD measurement system	Functional materials can react with moisture and oxygen in air, resulting in structural changes while potentially generating corrosive gases. The AIRGUARD solution allows safe handling of samples without air-contact.
Separation performance evaluation of mixed gas	For DAC, CCUS, and CCS applications, breakthrough curve measurements with multiple gaseous components such as CO ₂ and H ₂ O can be analyzed using dedicated highly stable and repeatable sensor detectors. Options: CO ₂ probes; CO ₂ / H ₂ O probes.

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SOFTWARE

The intuitive software is packed with powerful features that boost operator productivity. The advanced BELCAT II platform, refined over many years, enables easy execution of complex measurements while ensuring reliable and reproducible results through a range of sophisticated functions.

- | Simple operation measurement software
- | Automatic zero-point adjustment
- | Sequential measurement mode
- | High reliability with programmable multi-point calibration
- | Waveform analysis software
- | BELMASS II link software (option)
- | Pulse chemisorption analysis function



BELCAT II measurement view

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SOFTWARE SPECIFICATIONS

Simple operation measurement function	Dedicated tabs for standard analyses (TPR, TPD, TPO, and BET) enable easy programming and real-time monitoring of operational status, TCD charts, temperature, and flow rates.
Automatic zero-point adjustment of TCD	Automatic TCD zero-point adjustment ensures consistent baselines for reliable data comparison and accurate continuous measurements with different carrier gases.
Sequential measurement mode	Automates catalyst characterization by performing a series of independent measurements in a defined order, allowing for systematic analysis without user intervention.
Highly reliable automatic multi-point calibration	Performed after TPD or TPR measurements by using the instrument's MFCs to generate various gas concentrations.
Waveform analysis software	Automatic peak area calculation, spectrum overlay for comparison, waveform deconvolution for peak separation, and additional analysis tools for convenient processing.

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TYPICAL APPLICATIONS



Catalysts



Battery materials



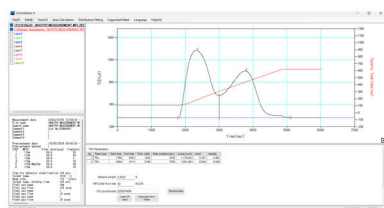
Cement

- | Catalysts
- | Battery materials
- | CCUS
- | Carbon
- | Zeolite
- | Cement
- | Ceramics
- | Fuel cells
- | Gas separation
- | MOF / PCP
- | Petrochemistry

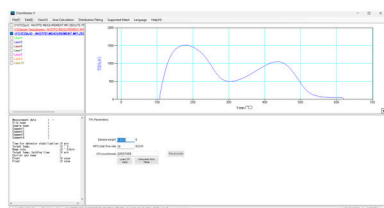
... and many more!

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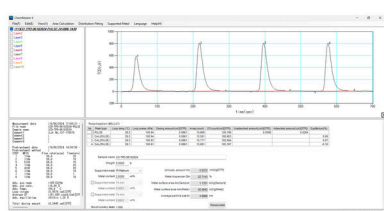
MEASUREMENT EXAMPLES

**NH₃-TPD MEASUREMENT RESULT OF TYPE MFI ZEOLITE**

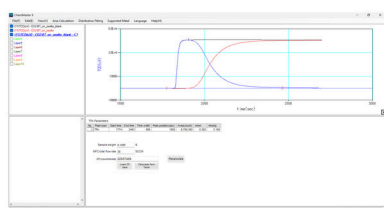
Desorption amount 0.835 mmol/g (2 = H peak value); Peak temperature 440 °C

**NH₃-TPD MEASUREMENT RESULT OF TYPE MFI ZEOLITE**

Convenient conversion of time-based data into temperature-dependent profiles.

**PT/AL₂O₃ METAL DISPERSION RATE BY CO PULSES**

Desorption amount: 0.527 cm³/g; metal dispersion rate: 22.7%; metal surface area: 1.13 m²/g; metal particle size: 4.99 nm. Fully automated base line correction and integration of pulses for effortless evaluation of data.

**CO₂ ADSORPTION BREAKTHROUGH CURVE MEASUREMENT**

Adsorbed CO₂ amount: 3.18 mmol/g. Blank measurement (black), break-through adsorption experiment (red) and calculated differences as adsorbed amount (blue). The combination with BELMASS II enables multi-component break through analysis.

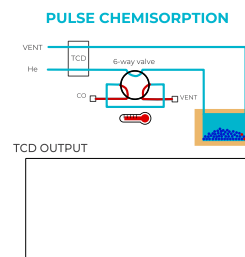
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BASIC CONCEPTS OF CATALYST CHARACTERIZATION

PULSE MEASUREMENT

The metal dispersion rate is a critical parameter in heterogeneous catalysis. It refers to the proportion of metal atoms that are exposed on the surface of a catalyst relative to the total number of metal atoms present (often expressed as a percentage). Metal dispersion can be calculated through pulse chemisorption using gases such as CO or H₂, which selectively chemisorb onto the metal surface.

This is achieved by continuously pulsing a specified amount of gas into the sample until saturation is reached. Pulse measurement determines the chemisorbed quantity by taking the saturated peaks as a reference. The difference in peak areas between unsaturated and saturated state is giving the adsorbed amount.



TEMPERATURE-PROGRAMMED DESORPTION MEASUREMENT (TPD)



This method examines the chemical adsorption characteristics on solid surfaces and is generally represented by a spectrum with desorbed gas concentration as the Y-coordinate and temperature as the X-coordinate. By continuously increasing the sample temperature and detecting the desorbed gas, it is possible to determine the amount and strength of energetically distinct adsorption sites.

NH₃-TPD evaluates acidic sites of solid acid catalysts, CO₂-TPD assesses basic sites of solid base catalysts; CO-TPD and H₂-TPD characterize active metal centers.

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TEMPERATURE-PROGRAMMED METHODS

TPR, TPO, TPX, and TPSR are powerful techniques for analyzing the reactivity of solid catalysts. These methods involve gradually increasing the sample temperature while monitoring the consumption of reactants or the formation of products – typically plotted with temperature on the X-axis and signal intensity on the Y-axis. This approach enables continuous observation of redox behavior and reaction dynamics, revealing key properties such as reduction temperature, oxidation potential, and reaction steps.

Temperature Programmed Reduction (TPR)

Temperature Programmed Oxidation (TPO)

- | Temperature Programmed Reduction (TPR): Characterization of reducibility and interaction of metal oxides and supported catalysts under temperature ramps with reducing gases.
- | Temperature Programmed Oxidation (TPO): Evaluation of oxidation states, coke deposition, and reactivity via programmed exposure to oxidizing gases.
- | Temperature Programmed Reaction (TPX): Study of catalytic reactions under varying temperature programs to simulate operational conditions.
- | Temperature Programmed Surface Reactions (TPSR): Enables precise monitoring of catalytic surface reactions as a function of temperature.

ADSORPTION BREAKTHROUGH CURVE MEASUREMENT

The breakthrough curve describes the concentration of an adsorbate passing an adsorption column over time. It is an essential tool for understanding how adsorbent material captures one or more components from a mixture of gases as it passes through the column.

Initial phase: the adsorbent effectively captures the adsorptive. Breakthrough point: its concentration in the effluent begins to rise. Equilibrium phase: the effluent and influent concentrations become equal as the adsorbent becomes fully saturated.

BET SPECIFIC SURFACE AREA ANALYSIS

The specific surface area, defined as the total surface area per unit dry mass of a solid, is an important parameter for the characterization of catalysts. It can be determined using the BET method measuring the amount of a gas (e.g. nitrogen) desorbed after the sample is cooled to liquid nitrogen temperature under a helium-diluted adsorptive gas flow and then returned to room temperature.

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TECHNICAL DATA

Measurement method	Dynamic flow method
Detector	Semi-diffusion type 4-element thermal conductivity detector (TCD)
Measurement / pretreatment ports	1
Usable gases	He, Ar, N ₂ , O ₂ , H ₂ , CO, CO ₂ , NH ₃ , N ₂ O, NO, etc.
Gas port connections: Total	8
Gas port connections: Carrier gas line	3 out of 8 (non-corrosion resistant lines)
Gas port connections: Mix line	8 out of 8 (including 2 corrosion resistant lines)
Gas port connections: Pretreatment / pulse line	8 out of 8 (including 2 corrosion resistant lines)
Mass flow controller: Carrier gas line	F.S. 100 sccm
Mass flow controller: Mix line	F.S. 30 sccm
Mass flow controller: Pretreatment / pulse line	F.S. 100 sccm
Electric furnace	Maximum temperature: 1200 °C (1100 °C for regular use) Quick cooling: 30 min (400→50 °C) Cryo cooling: 10 min (800→30 °C) CATCryo II: down to -120 °C Heating rate: 110 °C/min (50 to 500 °C) / 80 °C/min (50 to 1000 °C)
Vapor injection (Option)	H ₂ O, CH ₃ OH, C ₂ H ₅ OH, toluene, benzene, etc.
Dimensions (W x H x D), weight	500 x 750 x 500 mm, 80 kg
Requirement: Gas	Measurement gas: 0.1 MPa (gauge pressure) Compressed air: 0.45 to 0.55 MPa (gauge pressure); Joint: 1/8" Swagelok connection
Requirement: Power supply	Single-phase, AC110 / 220V
CE certified	yes
Vapor (optional): Temperature range	Bubbling bottle: Pyrex, 100 cc, 3 to 100 °C, temperature control via Peltier element
CATCryo II (optional): Temperature control method	LN ₂ spray + Heater
CATCryo II (optional): Temperature range	Temperature range: -120 ~ 1200°C (1100°C for regular use)
CATCryo II (optional): (LN ₂) reservoir volume	10 l
External gas mix unit (optional): Gas port	1 ~ 3 (upgradable to a maximum of 3 MFCs) Joint: 1/8-inch Swagelok connection
External gas mix unit (optional): Mass flow controller	F.S.: 30 sccm (0.6 ~ 30 sccm (N ₂)) Corrosion-resistant MFCs only.

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