3P Surface Area and Porosity Analyzers

- BET Surface Area
- Pore Size Distribution
- Pore Volume
- Adsorption Capacity
- Chemisorption Parameters
- Vapor Sorption
- Heat of Adsorption
- Research and Development
- Quality Control

STATIC-VOLUMETRIC AND DYNAMIC GAS ADSORPTION ANALYZERS

PARTICLE CHARACTERIZATION

POWDER ANALYSIS

PORE DETERMINATION

3P INSTRUMENTS

Characterization of
particles · powders · pores

info@3P-instruments.com
www.3P-instruments.com

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Up to three independent analysis ports for high-performance physical adsorption experiments of microporous materials, such as active carbon, zeolites, MOFs, etc

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Up to four independent analysis ports for the determination of meso and macro pores from 2 up to 500 nm

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Sorption analyzer with up to four measuring stations in one dewar: high sample throughput with small lab space requirement, combined with minimum liquid nitrogen consumption

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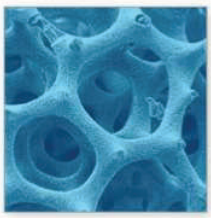
For mixed gas/vapor adsorption

Applications

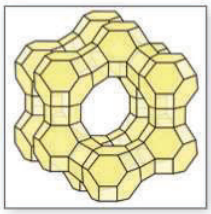
- Research and Development
- Quality Control
- Zeolites, MOFs, active carbon, silica gels, ...
- Determination of BET surface area
- Analysis of Pore Size Distribution and Pore Volume
- Determination of Chemisorption Parameters
- Vapor Sorption Measurements
- Determination of Adsorption Capacity and Heat of Adsorption

Introduction

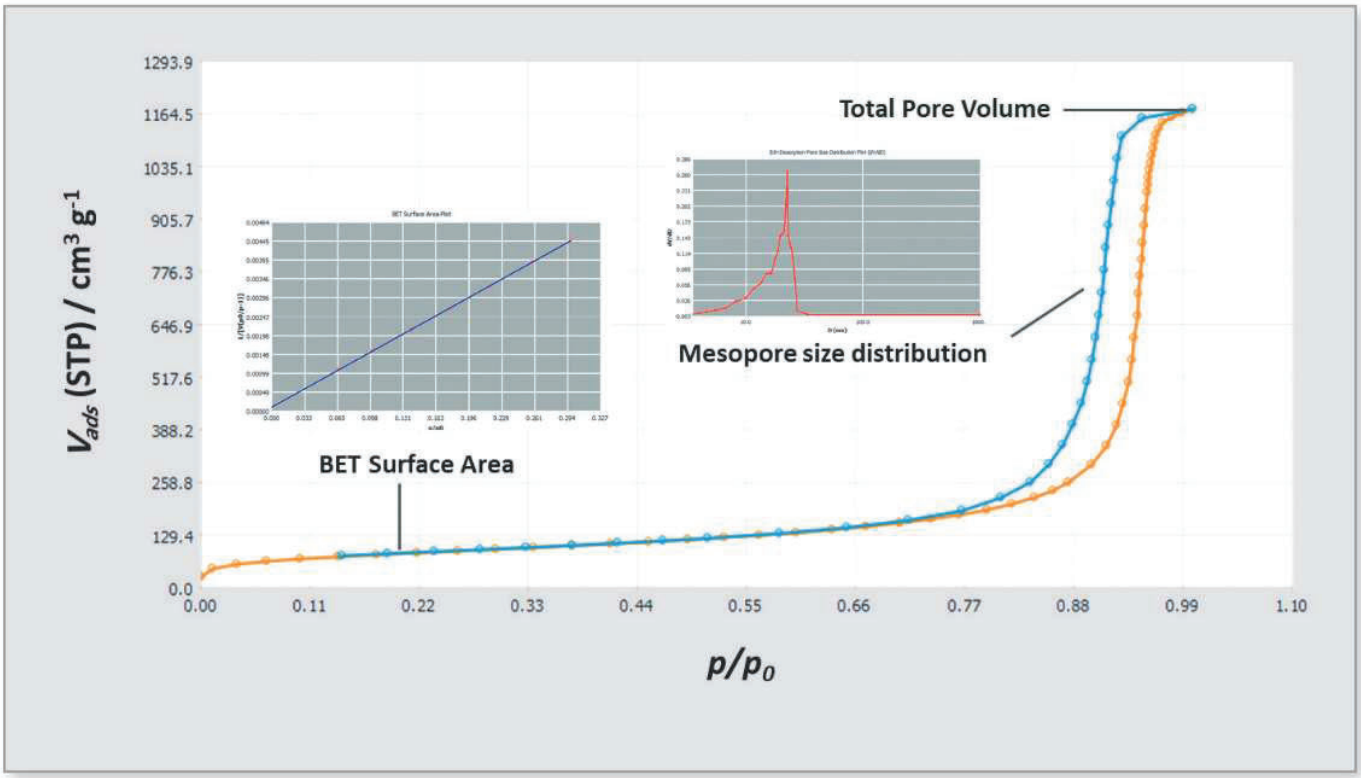


For 30 years, 3P Instruments has been standing for methods of the characterization of particles, powders and porous materials in Europe. The purpose of the department "Surfaces & Pores" is to offer professional consultation and scientific solutions concerning our analytical instruments and methods to customers in the fields of research, development, or quality control of powders and porous materials. We are mainly focused on the determination and evaluation of characteristics such as the BET surface area, pore size distribution, porosity, pore volume, adsorption capacity, chemisorption parameters, breakthrough analysis, mixed gas adsorption, density, and permeability.

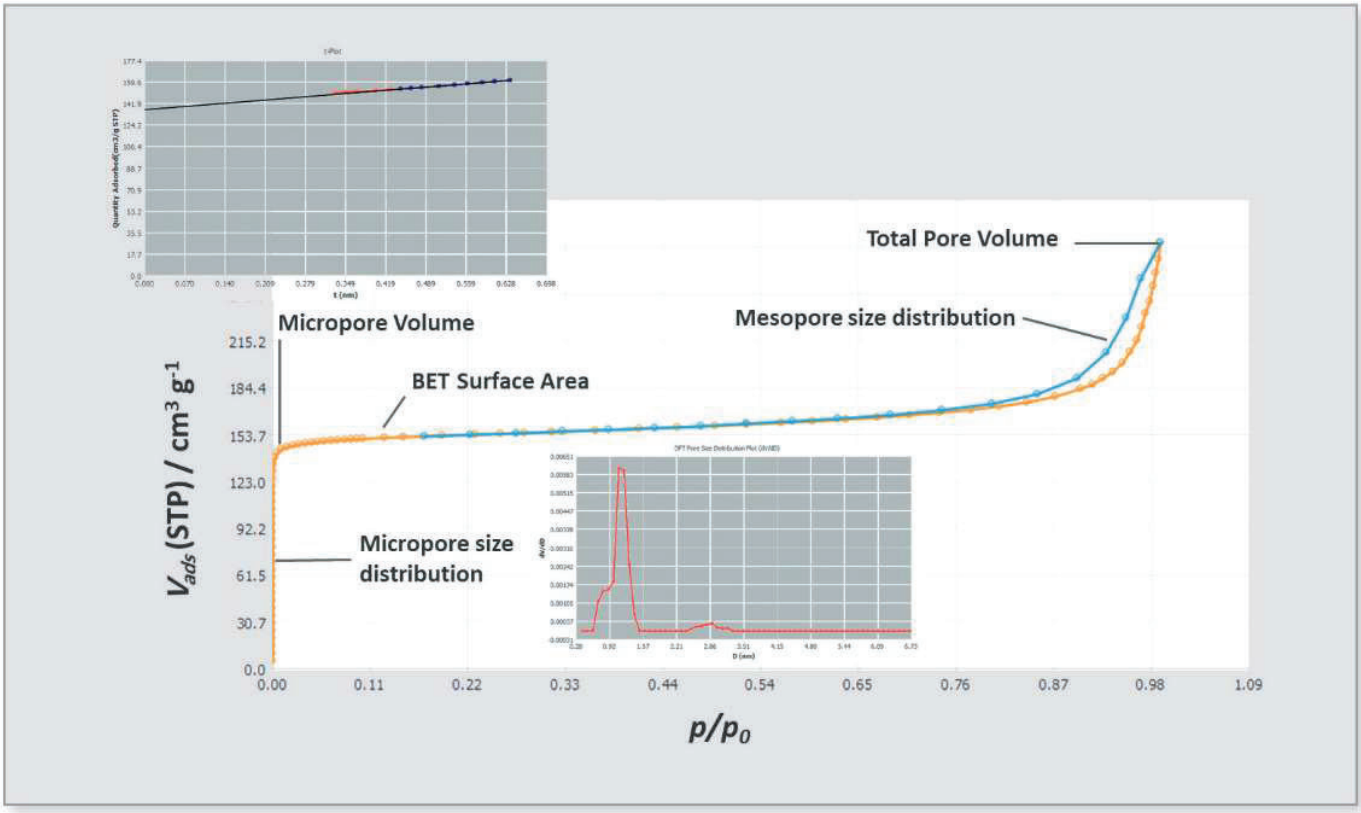
3P Gas Adsorption Analyzer Series



The characterization of surface areas and pores of solid materials are important parameters in many laboratories and are usually determined by gas adsorption equipment. These techniques can be complemented by adsorption of water and other vapors, chemisorption, high-pressure- and breakthrough measurements. 3P Instruments offers a broad range of different surface area and pore size analyzers, perfectly designed to meet your application requirements in terms of analysis parameters, flexibility, desired sample throughput, ease of use and analysis speed. This brochure gives an overview of our instrument models and possible configurations.



Example: Mesopore Analysis



Example: Micropore Analysis

3P meso series

The 3P meso series follows the principle of independent analysis ports for the determination of meso and macro pores from 2 up to 500 nm. One, two, and four port systems are available to optimally meet the costumers demands. Designed for the field of quality assurance and/or production control, these analyzers provide an independent dosing manifold equipped with 1000 Torr transducers for each measurement port. Each of the measurement stations include the capability to degas the sample in-situ (up to 400 °C). This principle avoids sample contamination during sample transfer from separate degassers to the analysis port without taking any further precautions. However, for materials where these effects are insignificant, external degassers are available as well.

Applicable methods and determinable parameters

- Isothermal adsorption and desorption curve
- BET specific surface area (single point, multi-point)
- Langmuir surface area
- External surface area (STSA)
- BJH pore size analysis
- t-plot analysis
- DR, DA, MP method
- HK pore size analysis
- SF pore size analysis
- NLDFT pore size distribution
- Pore size mode, average pore size, total pore volume
- Calculation of heat of adsorption, etc.

Benefits and Features

- The 3P meso series is available with one, two, or four **independent measurement station(s)** for high-resolution sorption measurement(s).
- Each measurement station has **its own set of pressure transducers** and each includes its own 1000 Torr p_0 transducer.
- Each measurement station has its **own gas input.** The system can run up to four different experiments at distinct temperatures and various gases simultaneously ***(Figure 1)***.
- **Software driven, fully programmable in-situ degassing** at each station. Additional degassers are optional ***(Figure 2)***.
- **Three step evacuation routine** for safe sample handling including very fine particles and high porous materials ***(Figure 3)***.
- Presentation of **real-time kinetic data (pressure versus time)** to check and visualize equilibrium conditions ***(Figure 4, see next page)***.
- **Density Measurement** via an optional pycnometry function.
- **Two step filter system** to protect the system against sample contamination.
- Change of dose amounts and equilibration settings **on-the-fly**, a restart of the analysis is not necessary ***(Figure 5, see next page)***.

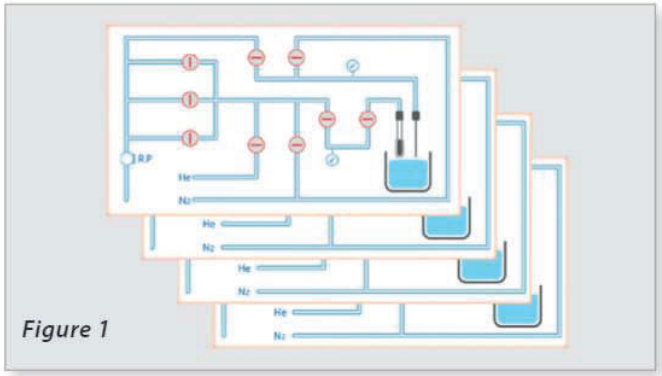


Figure 1

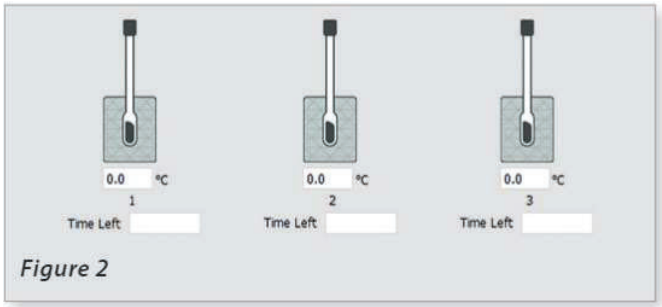


Figure 2

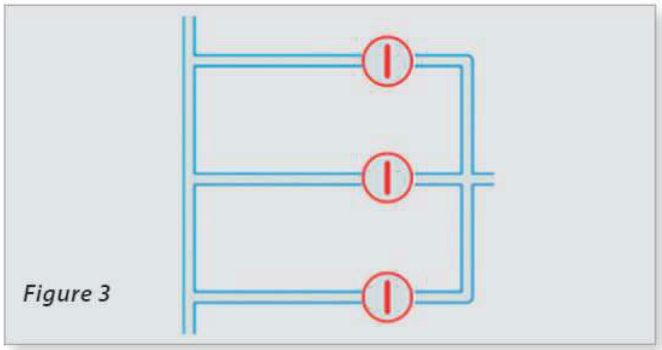


Figure 3

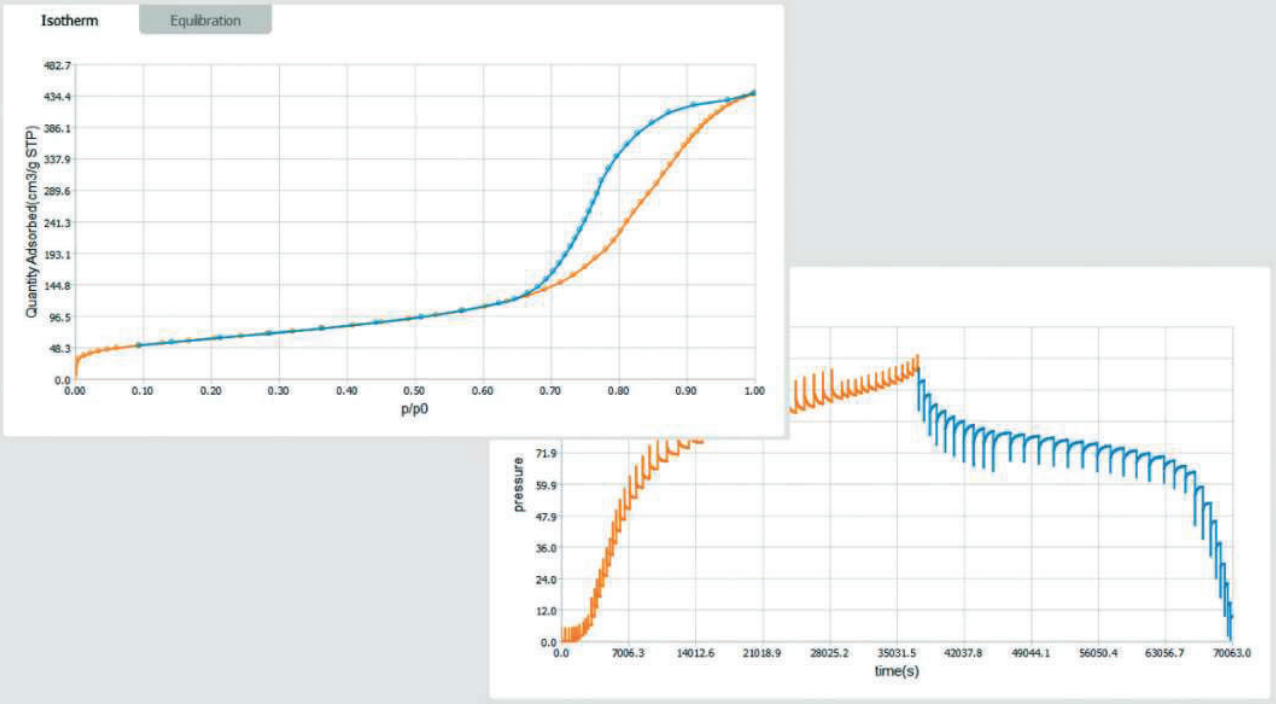
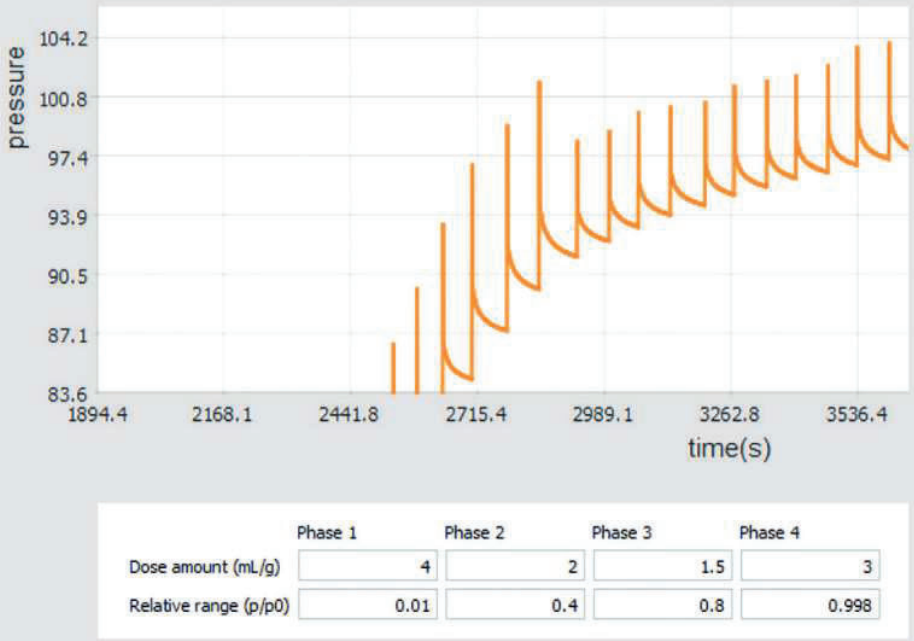


Figure 4



	Phase 1	Phase 2	Phase 3	Phase 4
Dose amount (mL/g)	4	2	1.5	3
Relative range (p/p0)	0.01	0.4	0.8	0.998

Figure 5

Specifications

Type	3P meso 112	3P meso 222	3P meso 400
Test Principle	Gas adsorption by static volumetric method		
Adsorbates	N_2, Ar, Kr, H_2, O_2, CO_2, CO, NH_3, CH_4, etc.		
Analysis Port(s)	1	2	4
p_0 Port(s)	1	2	4
Measurement Transducers	1	2	4
p_0 Transducers	1	2	4
Surface Area Range	0.0005 m^2/g to unknown upper limit; Measurement accuracy (standard sample) ≤ ± 1.0 %		
Pore Size Range	0.35 nm – 500 nm		
Minimum Pore Volume	0.0001 cm^3/g		
Pressure Sensor Accuracy	± 0.15 % (Full Scale)		
Range of Relative Pressure p/p_0	10^{-4} – 0.998		
Degassing Stations	2 in-situ	2 in-situ	4 in-situ
Degassing Temperature	Room temperature to 400 °C (optional 500 °C), accuracy: 1 °C		
Vacuum System	Mechanical vacuum pump (ultimate vacuum $6.7*10^{-2}$ Pa)		
Dimensions	L 740 x W 500 x H 940 mm	L 740 x W 500 x H 940 mm	L 840 W x 630 x H 940 mm
Weight	75 kg	75 kg	85 kg
Temperature Requirements of Environment	15 – 40 °C		
Humidity Requirements of Environment	10 % – 90 %		
Power Requirements	AC 220 V ± 20 V, 50/60 Hz, maximum power 300 W, current 5 A		

Optional Accessories and Tools

Optional Accessories and Tools	3P micro	3P meso	3P sync
3P prep J4: Additional sample preparation system with 4 stations and a max. degasser temperature of 400°C. It offers an optional turbo vacuum and temperature ramp control *(Figure 1)*.	■	■	■
Vapor source with heated manifold up to 50 °C *(Figure 2)*.	■		
Tempering Kit for experiments from 0 to 50°C. It is most commonly used for CO_2, n-Butane or vapor experiments *(Figure 3)*.	■	■	■
cryoTune series: Cryostatic accessory/temperature controller for adsorption using various adsorptives at temperatures 77–323 K. It needs only liquid nitrogen for cooling. It allows the characterization of microporous solids according to ISO 9277 and IUPAC 2015 recommendation, but also the determination of BET surface of other materials by Ar/Kr instead of N_2 adsorption. It operates noiseless and has a very low energy consumption *(Figure 4)*.	■	■	■
cryoCooler: Can be used for cryogen free temperature control for measurement temperatures < 20–320 K *(Figure 5)*.	■		
Simulation software 3P sim to predict the performance of dynamic experiments or mixed gas experiments *(Figure 6, right page)*.	■	■	■

Figure 1

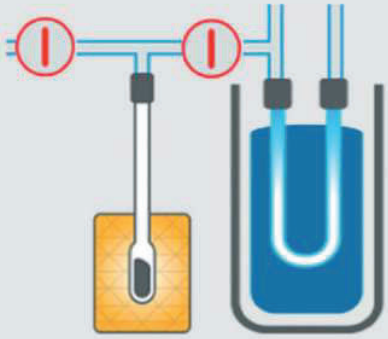


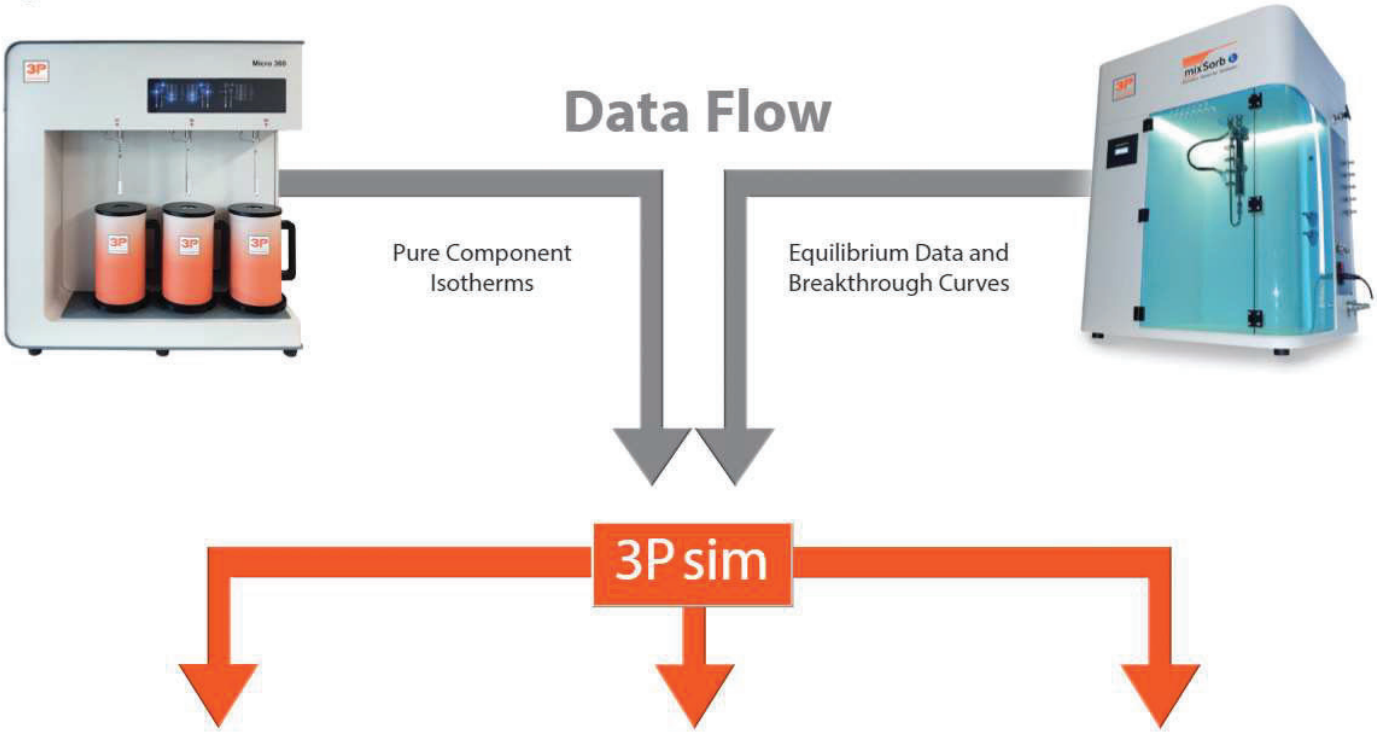
Figure 2

Figure 3

Figure 4

Figure 5

Figure 6



Isotherm Fitting

With **3P sim** measured isotherm data can be fitted with the following mathematical isotherm models:

- HENRY
- LANGMUIR
- TOTH
- SIPS
- FREUNDLICH
- DUALSITE LANGMUIR
- DUALSITE LANGMUIR SIPS

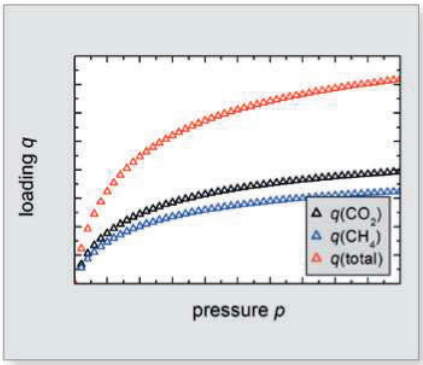
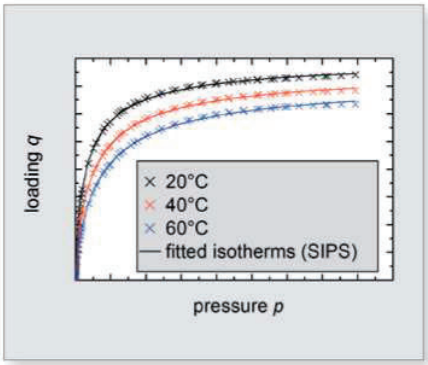
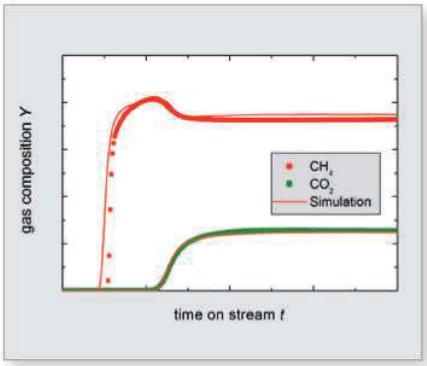
Prediction of Mixture Equilibria

The program allows the calculation of total and partial loadings at given pressures or compositions and supports the following theories:

- IAST* with LANGMUIR
- IAST with TOTH
- IAST with DUALSITE LANGMUIR
- IAST with DUALS. LANGMUIR SIPS
- Multicomponent LANGMUIR
- Multicomponent SIPS

* Ideal Adsorption Solution Theory

Dynamic Simulation

- **3P sim** provides solutions for mass- and energy balances which allow simulations without user precognition or programming skills.
- Technically relevant transport parameters (e.g., LDF* constants) are accessible
- Simulation of breakthrough curves and temperature profiles

* Linear Driving Force