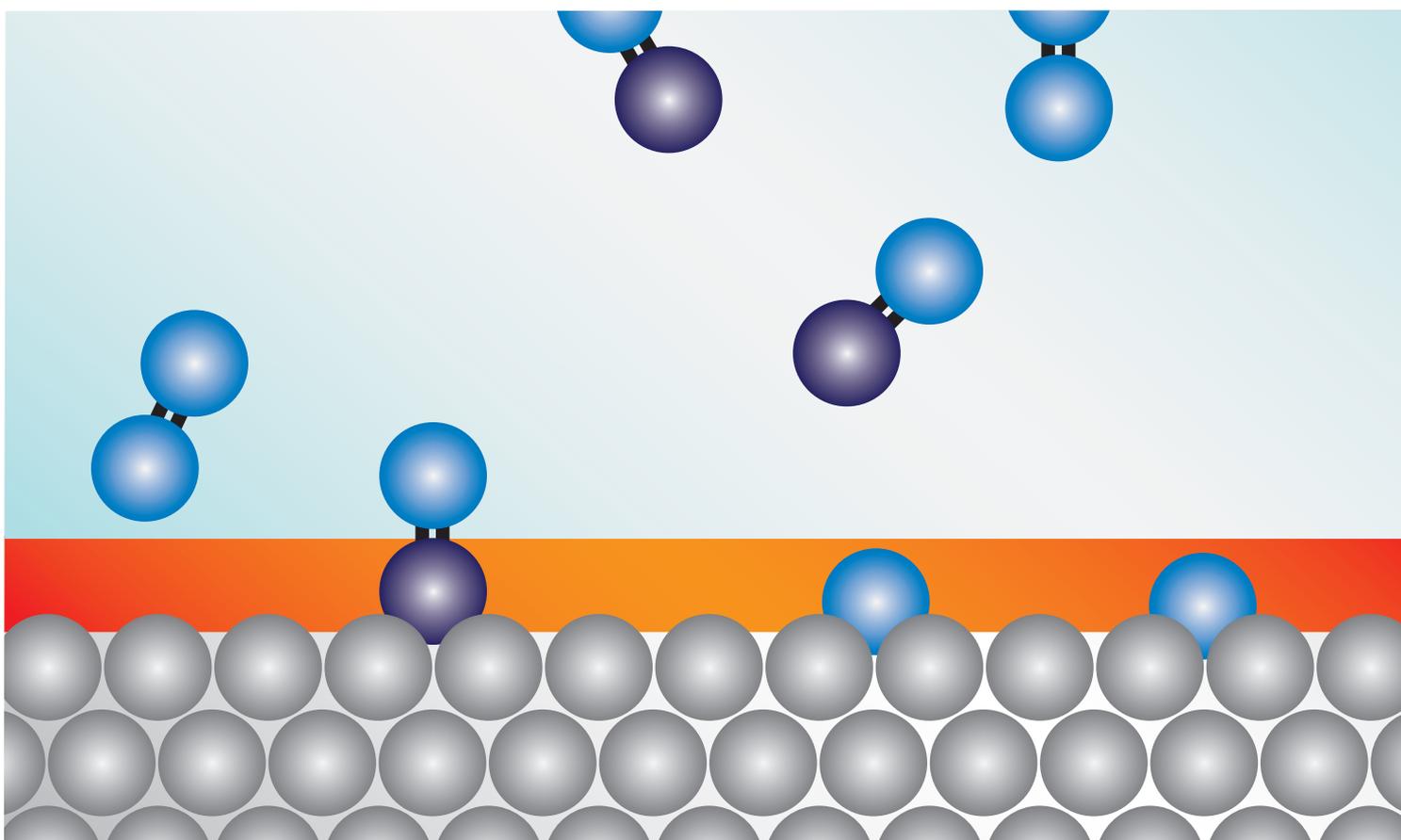


**LINSEIS**

T H E R M A L   A N A L Y S I S

**GRAVIMETRIC  
SORPTION  
ANALYZERS**

GSA PT 10  
GSA PT 100  
GSA PT 1000



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Since 1957 LINSEIS Corporation has been delivering outstanding service, know how and leading innovative products in the field of thermal analysis and thermo physical properties.

Customer satisfaction, innovation, flexibility and high quality are what LINSEIS represents. Thanks to these fundamentals, our company enjoys an exceptional reputation among the leading scientific and industrial organizations. LINSEIS has been offering highly innovative benchmark products for many years.

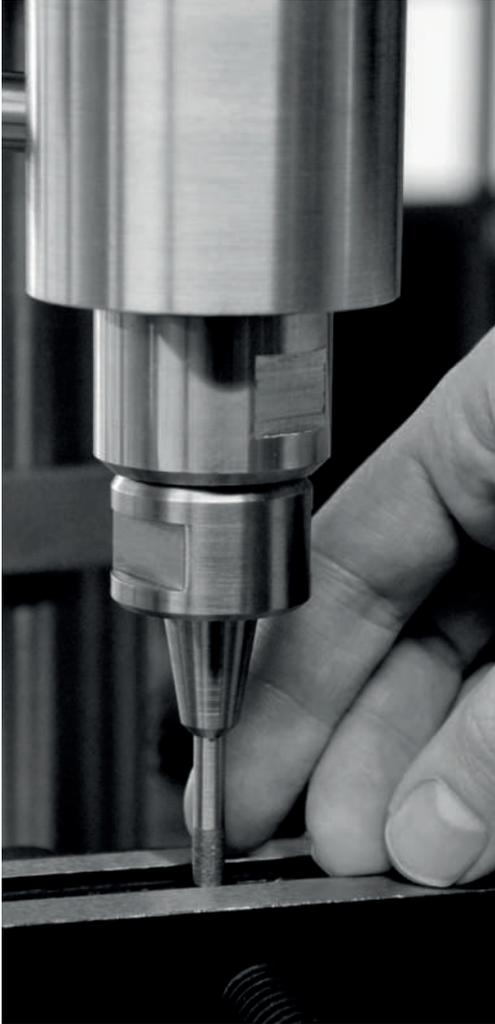
The LINSEIS business unit of thermal analysis is involved in the complete range of thermo analytical equipment for R&D as well as quality control. We support applications in sectors such as polymers, chemical industry, inorganic building materials and environmental analytics. In addition, thermo physical properties of solids, liquids and melts can be analyzed.

LINSEIS provides technological leadership. We develop and manufacture thermo analytic and thermo physical testing equipment to the highest standards and precision. Due to our innovative drive and precision, we are a leading manufacturer of thermal Analysis equipment.

The development of thermo analytical testing machines requires significant research and a high degree of precision. LINSEIS Corp. invests in this research to the benefit of our customers.

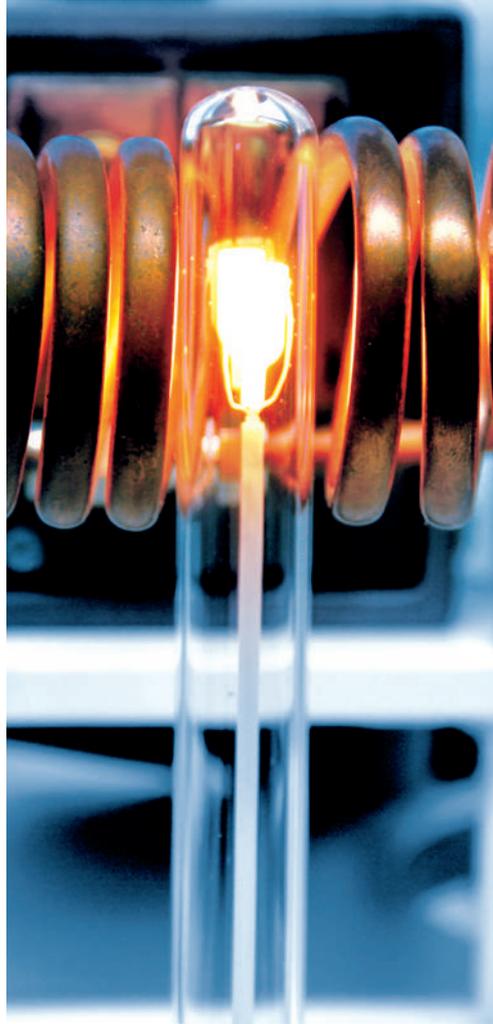


**Claus Linseis**  
*Managing Director*



## German engineering

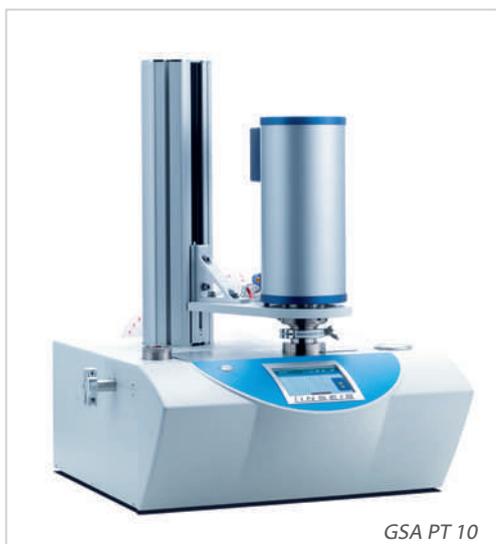
The strive for the best due diligence and accountability is part of our DNA. Our history is affected by German engineering and strict quality control.



## Innovation

We want to deliver the latest and best technology for our customers. LINSEIS continues to innovate and enhance our existing thermal analyzers. Our goal is constantly develop new technologies to enable continued discovery in science.

# GSA – GRAVIMETRIC SORPTION ANALYZERS



**Chemisorption/Physisorption (UHV to 1000 bar)**

**Adsorption Isotherms (BET Surface Analysis)**

**TPD, TPO, TPR measurements (-196 to 1800°C)**

**Sorption Enthalpies (Simultaneous TG/DSC-sensor)**

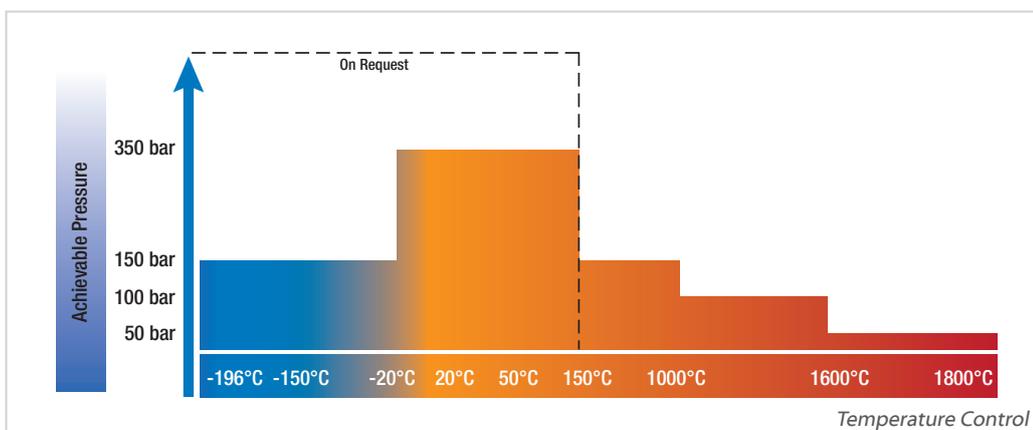
**In-situ Gas Analysis (FTIR, Raman, ELIF)**

**Corrosive Atmospheres Magnetic Suspension Balance**



The adsorption or desorption of various gases by materials like catalysts or porous structures is one special, but very frequently asked application on thermo-balances. In general, there are two ways of monitoring adsorption and desorption, the volumetric sorption, where a definite amount of gas is brought into a sample chamber and the pressure change provides the information, and the gravimetric sorption, where the mass change of the sample is analyzed. With

our thermo-balance series, we use the gravimetric sorption setup which is possible due to our high resolution balance cells that can monitor very small mass changes over a broad pressure range. This enables the instrument to analyze precisely the adsorption and desorption behavior of various materials in a temperature range from -196°C to 1800°C and a pressure range of 0.01 mbar to 300 bars.



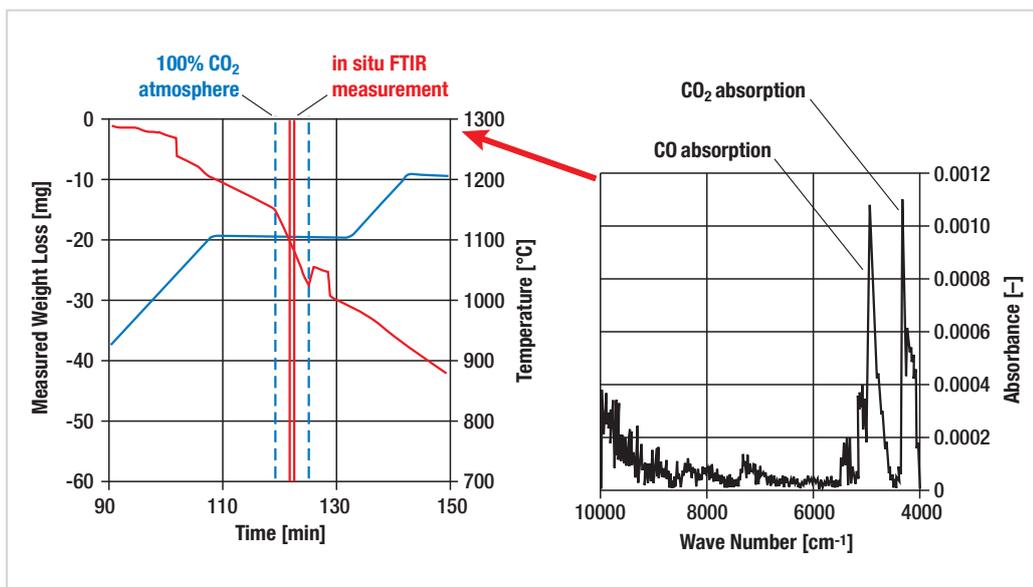
There are a lot of advantages coming up with gravimetric sorption: If a DSC measurement system is used, there is also the possibility to detect the sorption enthalpy during the measurement, what can provide very interesting information about the adsorption process as well. Another point is the flexibility in measurement systems and sample volumes that can be some milligram or even some gram using different sample holders.

The gravimetric sorption is the easier, faster and more flexible method to get information about gas adsorption, even if the accuracy of volumetric sorption can't be reached so far.

The following devices can be used for gravimetric sorption analysis:

- GSA PT 10 (STA PT 1600)
- GSA PT 100 (MSB)
- GSA PT 1000 (STA HP)

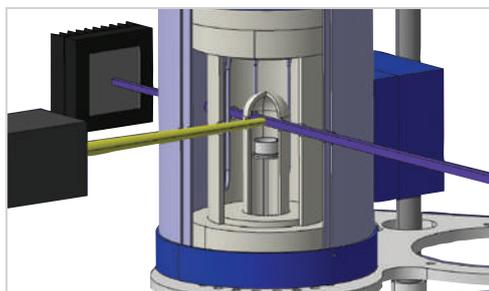
# FTIR COUPLING



All LINSEIS gravimetric sorption systems can be coupled with additional analyzing tools like FTIR. In the experiment charcoal was gasified in CO<sub>2</sub> atmosphere. Therefore the coal sample was placed in the instrument and the temperature at constant pressure of CO<sub>2</sub> was increased. During an isothermal segment at 1100°C, a huge mass loss could be observed, which symbolizes the gasification of the bound carbon (following the equation  $C+CO_2 \rightarrow 2 CO$ ).

The graphic shows the in-situ FTIR measurement during gasification of coal in a TGA system. (Sample temperature: 1100°C, pure CO<sub>2</sub>

atmosphere at a gas flow rate of 20 ml/min at 273K, 0.013 bars) The FTIR measurement was taken for 30s during the main mass loss step. The CO and CO<sub>2</sub> signals can be clearly seen in the IR spectrum, proving the release of CO gas during the mass loss step.



# SPECIFICATIONS

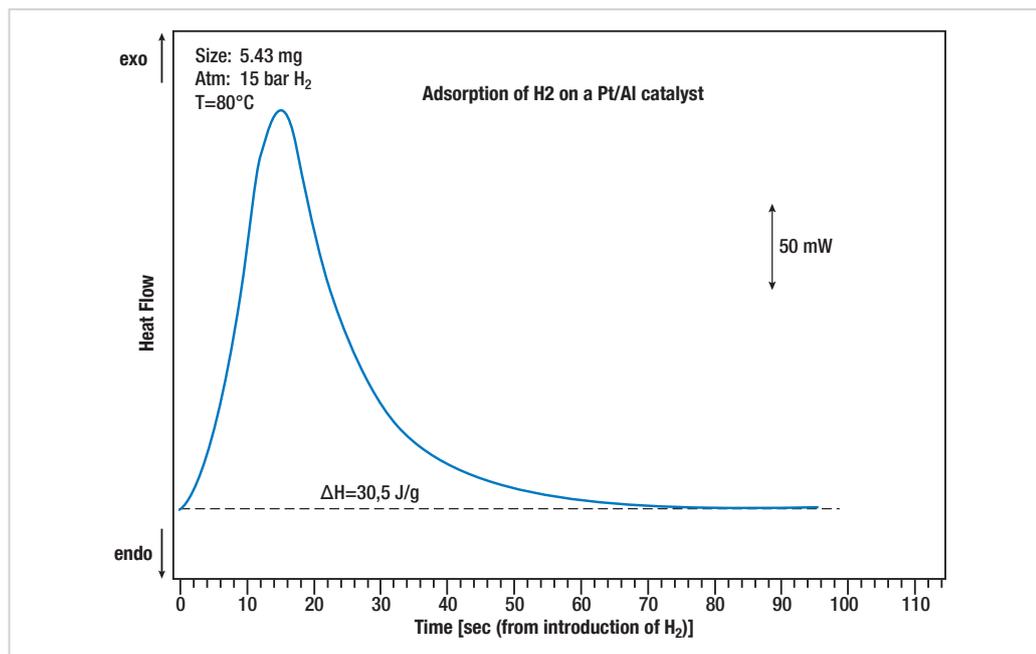
	<b>GSA PT10</b>
<b>Temperature range</b>	-150 bis 500/700/1000°C RT bis 1400/1600°C
<b>Heating rates</b>	0.01 up to 100°C/min
<b>Sample weight</b>	5 / 25 / 35 g (higher sample weights on request)
<b>Resolution</b>	0.025 / 0.1 µg
<b>Vacuum</b>	10 <sup>-5</sup> mbar
<b>Pressure</b>	optional 5/10 bar
<b>Detector</b>	TG, TG – DTA,
<b>Sensor</b>	(E/K/S/B)
<b>Electronics</b>	integrated
<b>Interface</b>	USB

	<b>GSA PT100</b>
<b>Temperature range</b>	-170°C up to 1250/1400/1600/1800°C max. 150 bar (different Versions)
<b>Max. pressure</b>	300 bar on request
<b>Vacuum</b>	10 <sup>-4</sup> mbar
<b>TGA</b>	
<b>Max. sample mass</b>	2/15g (higher sample weights on request)
<b>Resolution</b>	0.1 µg
<b>DSC</b>	
<b>DSC resolution</b>	0,3/0,4/1 µW
<b>DSC sensors</b>	E, K, S, C
<b>Options</b>	Pressure controlable Gas Mixing System (MFC's)
<b>Atmospheres</b>	inert, oxid.*, red., vac

	<b>GSA PT1000</b>
<b>Temperature &amp; pressure range</b>	RT up to 1100°C and max. 150 bar RT up tp 1400/1800°C and max. 50 bar
<b>Pressure range</b>	UHV – Ultra High Vacuum to 150 bar
<b>Probengewicht</b>	10 g (standard balance)
<b>Resolution</b>	1 ug
<b>Evolved Gas Analysis</b>	MS/FTIR possible
<b>Options</b>	Special custom versions can be realized

# APPLICATIONS

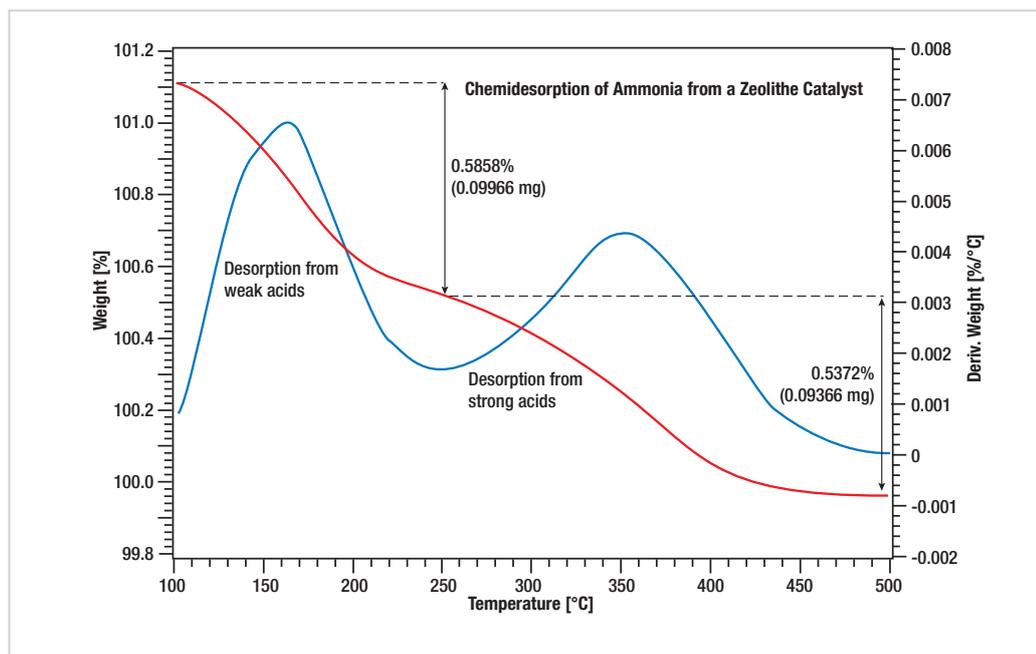
## Fast and Easy determination of Sorption Heats



The measurement of sorption, oxidation or reduction heats of catalysts performed with volumetric methods are normally very time-consuming and need many hours. The LINSEIS Gravimetric Sorption Analyzer STA HP, which measures both weight change and DSC-signal, provides a much faster alternative. Within 15 minutes or less the sorption heats can be measured.

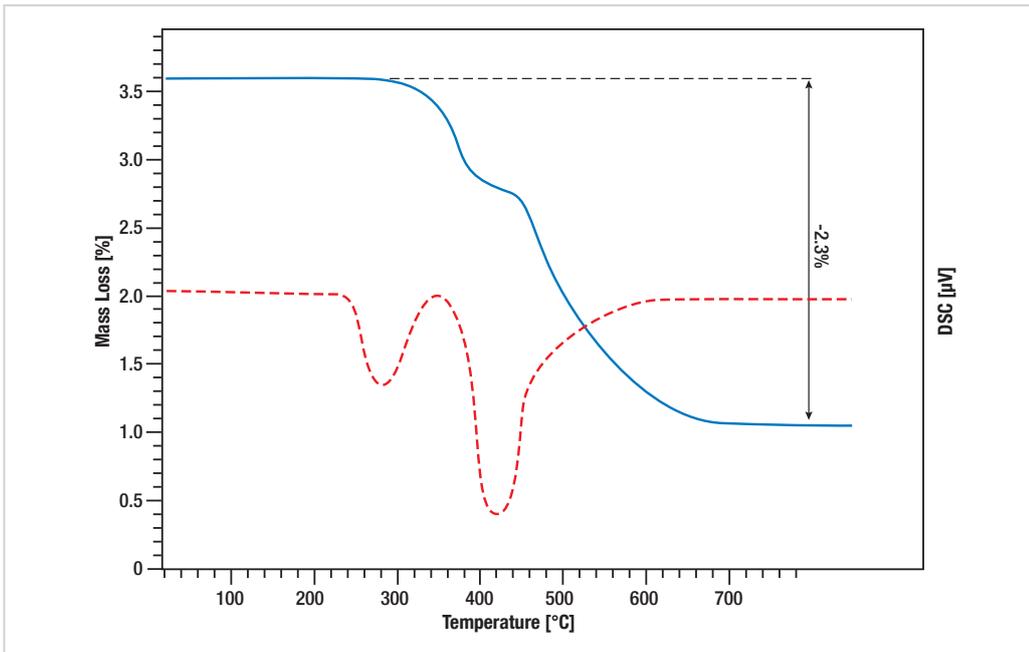
Chemisorption and catalytic oxidation or reduction are exothermic reactions. The heat involved can be easily monitored with the integrated DSC-sensor of the LINSEIS STA HP. The figure above shows the DSC-signal of the adsorption of Hydrogen on a Pt/Al catalyst at a pressure of 15 bar and a temperature of 80°C. The evolved heat is 30,5 J/g.

## TPD, TPO and TPR measurements



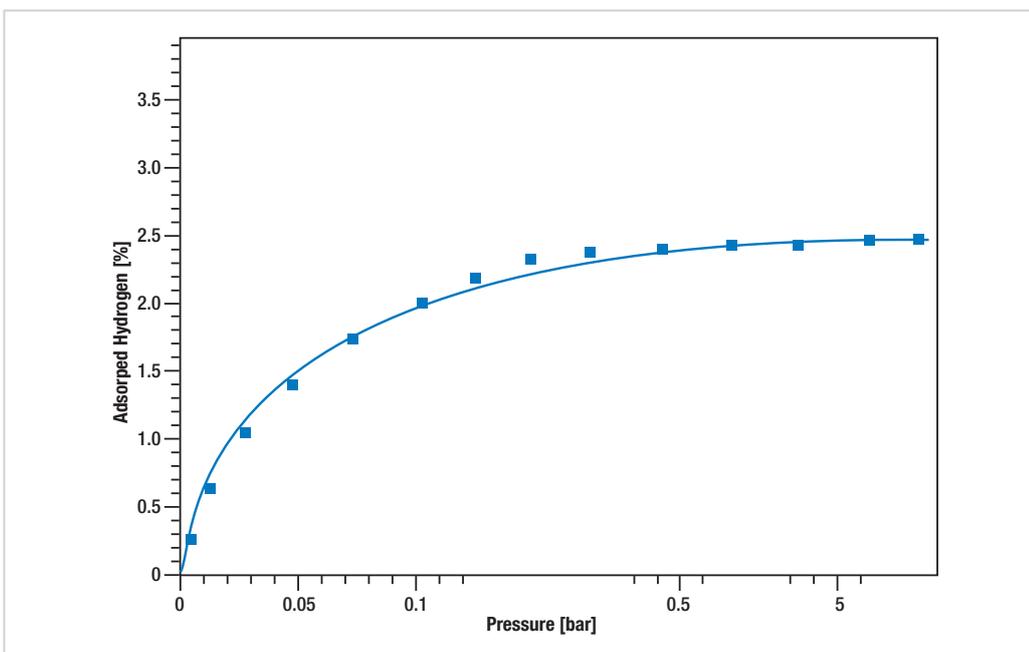
The distribution and relative strength of acid sites in zeolithes are important indicators of its catalytic properties. The acidity of zeolithes can be accurately measured with the temperature programmed desorption (TPD) of a base from the zeolithe surface. The Linseis gravimetric Sorption Analyzers are useful tools for characterizing TPD, TPO or TPR profiles. The figure above shows the chemidesorption of ammonia from a zeolithe catalyst surface. Weakly bound ammonia molecules are desorped between 100 and 250 °C. Between 260 and 500 °C strongly bound ammonia is desorped. The amounts of desorped ammonia can be quantitatively measured, i.e. it is possible to quantitatively identify the number of strong and weak acid sites present in the sample.

## Desorption of Hydrogen on TiH<sub>2</sub>



In this application example, desorption of hydrogen of Titanium hydride was monitored. Titanium hydride is a common used hydrogen resource for controlled release of hydrogen in various reactions. To get an idea what amount of hydrogen is released at what temperature, desorption was studied using a LINSEIS STA PT1600 system. TG and DSC signal were measured from RT to 800°C while the sample was heated linear in Argon atmosphere with 10K/min. Between 300°C and 600°C, there is a two-step mass loss of 2.3% in total which means the complete amount of bound hydrogen is released in that process. The DSC curve shows the corresponding Desorption peaks.

## Hydrogen adsorption on titanium at 700°C



In the current research on batteries and energy storage, the possibility of hydrogen of various materials storage is investigated very frequently. Hydrogen can be used as energy carrier that could be created and stored and then released when its needed. However, hydrogen is a very small, highly mobile molecule that shows high diffusion rates through any material. Therefore, the storage is a huge issue. In this measurement, the storage capabilities of hydrogen on a titanium alloy were tested at different pressures. The diagram shows that the amount of bound hydrogen (that can be detected by mass increase of the sample) increases over pressure until a plateau is reached at around 1 bar. This is where the material is saturated, carrying around 2.5 mass percent hydrogen.

**LINSEIS GmbH Germany**

Vielitzerstr. 43

95100 Selb

Tel.: (+49) 9287 880 0

E-mail: [info@linseis.de](mailto:info@linseis.de)**LINSEIS Inc. USA**

109 North Gold Drive

Robbinsville, NJ 08691

Tel.: (+1) 609 223 2070

E-mail: [info@linseis.de](mailto:info@linseis.de)**LINSEIS China**

Kaige Scientific Park 2653 Hunan Road

201315 Shanghai

Tel.: 61 90 12 03

Tel.: 50 55 06 42

E-mail: [info@linseis.com.cn](mailto:info@linseis.com.cn)**LINSEIS France**

1 Route de Trévoux

69250 Neuville/Saone

Tel.: (+33) 6.24.72.33.31

E-mail: [contact@ribori-instrumentation.com](mailto:contact@ribori-instrumentation.com)**LINSEIS Poland**

ul. Dabrowskiego 1

05-800 Pruszków

Tel.: (+48) 692 773 795

E-mail: [info@linseis.de](mailto:info@linseis.de)**[www.linseis.com](http://www.linseis.com)****Products:** DIL, TG, STA, DSC, HDSC, DTA, TMA, MS/FTIR, In-Situ EGA, Laser Flash, Seebeck Effect, Thin Film Analyzer, Hall-Effect**Services:** Service Lab, Calibration Service

03/20

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