



Simultaneous Thermal Analyzer – STA 449 **F3** Jupiter®

Method, Technique, Applications



Flexible,
Sophisticated &
Technically Outstanding

Simultaneous Thermal Analysis generally refers to the simultaneous application of Thermogravimetry (TGA) and Differential Scanning Calorimetry (DSC) to one and the same sample in a single instrument. The advantages are obvious: The test conditions are perfectly identical for the TGA and DSC signals (same atmosphere, gas flow rate, vapor pressure on the sample, heating rate, thermal contact to the sample crucible and sensor, radiation effect, etc.). Furthermore, sample throughput is improved as more information can be gathered from each test run.

DSC Possibilities

- Melting/crystallization behavior
- Solid-solid transitions
- Polymorphism
- Degree of crystallinity
- Glass transitions
- Cross-linking reactions
- Oxidative stability
- *Purity Determination*
- Specific heat capacity
- *Thermokinetics*

TGA Possibilities

- Mass changes
- Temperature stability
- Oxidation/reduction behavior
- Decomposition
- Corrosion studies
- Compositional analysis
- *Thermokinetics*

Standard*	Description
ISO 11358	Plastics – Thermogravimetry (TG) of Polymers
ASTM E793	Standard Test Method for Enthalpies of Fusion and Crystallization by Differential Scanning Calorimetry
DIN 51004	Thermal Analysis; Determination of Melting Temperatures of Crystalline Materials by Differential Thermal Analysis
DIN 51006	Thermal analysis (TA); Thermogravimetry (TG); Principles
DIN 51007	Thermal Analysis; Differential Thermal Analysis; Principles

* Depending on instrument setup

World-Leading Flexibility for Your Applications

The STA 449 **F3 Jupiter**® combines a high-performance Heat-Flux DSC with a submicrogram-resolution thermobalance, thereby offering an unmatched sample load and measurement range. The Simultaneous Thermal Analyzer can easily be adjusted to nearly any possible application by selecting the optimum furnace, installing the most appropriate sensor and using the proper accessories. The robust system setup, user-friendly software and flexible design along with the wide range of different options make the system an ideal tool for quality control and research for material characterization.

Setting New Benchmarks through Experience & Innovation



Top-Loading – The Standard for Balance Systems

The STA 449 **F3 Jupiter**[®] is a top-loading system using a balance design that has been standard for a long time in other types of scales – in laboratories and even in the kitchen at home or in a supermarket, most balances have been top-loading for decades. The reasons are simple: These systems combine ideal performance with easy handling.

Why should your thermobalance be any different?

Stability, Low Drift and High Sample Loads

The balance system of the STA 449 **F3 Jupiter**[®] offers high sample loads (up to 35 grams) and measurement range (35 grams) as well as high resolution (0.1 µg) and low drift (in the microgram range over hours). Another outstanding feature of the balance section of the STA is its high accuracy.

Defined Atmosphere Conditions – Vacuum-Tight Design

The STA 449 **F3 Jupiter**[®] is vacuum-tight by design. Several pump systems can be connected to the STA which allow evacuation down to 10⁻⁴ mbar and back-filling with well-defined atmospheres. The unique **OTS**[®] (oxygen trapping system) accessory can be used to reduce the oxygen partial pressure at the sample.

– 50 YEARS –
Leading Manufacturer of
High-Performance
Thermal Analysis Systems

STA 449 **F3 Jupiter**[®]

Trend-Setting Technology





Select the Appropriate

Ten interchangeable furnaces are available to accommodate different application areas across the entire temperature range (-150°C to 2400°C). A double furnace hoist allows the simultaneous installation of two different furnaces for improved sample throughput or for low- and high-temperature tests with the same instrument. The furnaces can easily be changed by the operator. Therefore, the system is adaptable to any future application range.



Day-to-Day Work Done Safely

For standard STA measurements, the silicon carbide furnace (SiC) is the robust workhorse in your laboratory, operating from ambient temperature to 1600°C. For measurements under corrosive atmosphere, the SiC furnace can be equipped with a protected TGA-DTA sensor, guaranteeing instrument-safe conditions.

Measurements in the Lower Temperature Range

The silver and steel furnaces allow for measurements in the subambient temperature range by using devices for controlled cooling. Whereas the silver furnace is ideally suited for the determination of the specific heat capacity, the steel furnace offers a broad temperature range from -150°C to 1000°C.

Specific Heat Capacity at Higher Temperatures

The platinum and the rhodium furnaces in combination with dedicated DSC sensors are specifically suited for determination of the specific heat capacity in the higher temperature range.

Your Results Achieved at the Highest Speed

The high-speed furnace allows for the simulation of realistic heating processes with linear heating rates up to 1000 K/min. Additionally, the high heating rates are useful when implementing kinetic studies.



Furnace

for Your Application!

Highest Temperatures

The tungsten heating element allows for measurements under helium atmosphere from room temperature to 2400°C and high-vacuum measurements from 400°C to 2400°C.

Measurements in Humid Atmospheres

The copper furnace is ideal for measurements under relative humidity between room temperature and 100°C. For this purpose, a humidity generator is available which offers a maximum dewpoint of 80°C corresponding to 47% molar concentration. In addition, the copper furnace can be used for conventional STA measurements including determination of the specific heat capacity up to 500°C.

The water-vapor furnace covers the broad temperature range from room temperature to 1250°C. The furnace can be connected to the aforementioned humidity generator, or to a vapor generator which produces steam by evaporating water. A molar concentration of up to 100% can be achieved.

Furnace type	Temperature range	Cooling system
Silver	-120°C to 675°C	liquid nitrogen*
Copper	-150°C to 500°C	liquid nitrogen*
Steel	-150°C to 1000°C	liquid nitrogen*
Platinum	RT to 1500°C	forced air
Silicon carbide	RT to 1600°C	forced air
Rhodium	RT to 1650°C	forced air
Graphite	RT to 2000°C	tap or chilled water
Water-vapor	RT to 1250°C	forced air
High-speed	RT to 1250°C	forced air
Tungsten	RT to 2400°C	tap or chilled water

* Alternative vortex cooling allows for start temperatures around 0°C.

The Right Sensor for Your Demands

Various Sensors

The STA 449 **F3 Jupiter**[®] can be equipped with different sensor types. TGA sensors with slip-on plates or large crucibles (up to 5 ml) allow tests on large sample volumes and masses. TGA-DTA sensors can be used for applications such as routine tests or measurements on aggressive sample substances. For special applications such as tests under corrosive atmospheres, the protected sensors can be employed. The TGA-DSC and TGA-DSC- c_p sensors are used for most tests and allow quantitative DSC testing simultaneously to the TGA results. The c_p versions additionally allow determination of the specific heat capacity with high accuracy.

The *Quick-Connect* connection of the sensors to the instrument allows sensors to be changed in a matter of seconds. This allows the system to be easily adapted to any of the various potential applications.

Sensor thermocouple	Temperature range	Sensor types	Atmospheres
Type E	-150°C to 700°C*	TGA-DTA, TGA-DSC (c_p)	inert, red., oxid., vac.
Type K	-150°C to 800°C*	TGA-DTA, TGA-DSC (c_p)	inert, red., oxid., vac.
Type S	RT to 1650°C	TGA, TGA-DTA, TGA-DSC (c_p)	inert, red., oxid., vac.
Type S protected	RT to 1650°C	TGA, TGA-DTA	inert, red., oxid., vac., corr.
Type P	-150°C to 1000°C	TGA, TGA-DSC, TGA-DSC (c_p)	inert, red., oxid., vac.
Type B	RT to 1750°C	TGA, TGA-DTA, TGA-DSC	inert, red., oxid., vac.
Type W	RT to 2400°C	TGA, TGA-DTA	inert, red., vac.

* in oxid. atmosphere up to 500 °C

Standard Type S Sensors – Workhorse and Specialty

In the high-temperature range, type S sensors combine a broad temperature range from room temperature to 1650°C with high sensitivity. For measurements in the presence of corrosive gases, the TGA-DTA sensor with protected thermocouples provides safe conditions without adversely affecting the sensitivity.

High Sensitivity in the Lower Temperature Range

The type P sensors are standard in the lower temperature range; they are ideally suited for the steel furnace. All sensors equipped with thermocouple E or K are characterized by the highest level of sensitivity and resolution. They are particularly well suited for detecting small effects.

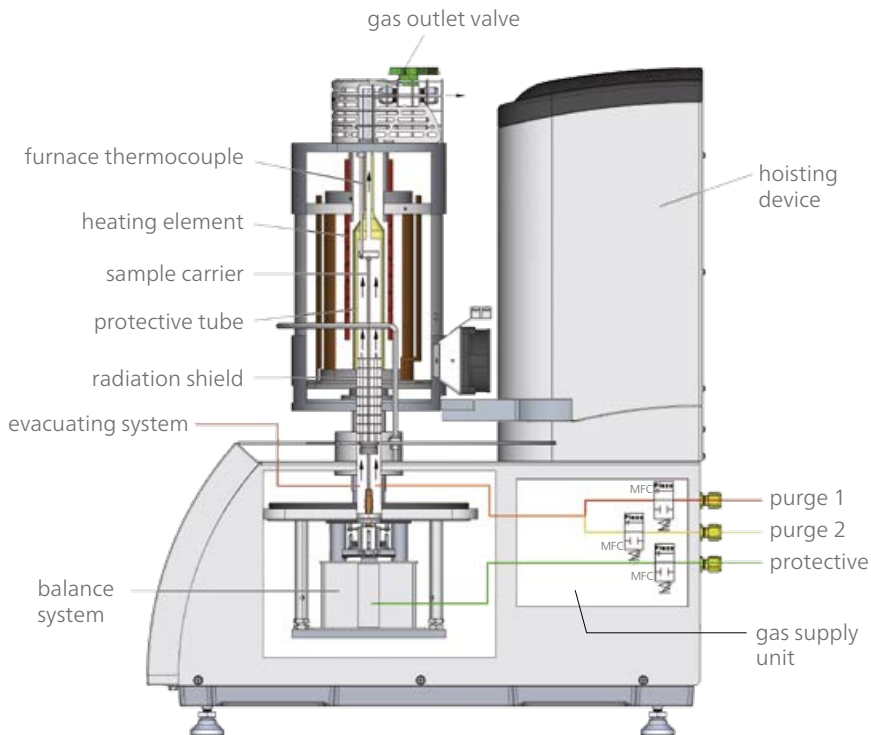
High and Highest Temperature Range

True DSC measurements up to 1750°C can be monitored by using the type B sensor. At the highest temperatures up to 2400°C, the type W sensor for TGA and TGA-DTA can be used under inert, reducing, and vacuum conditions.

HIGHEST PRECISION

Maximum Flexibility





Gas Flow Control

The gas flow is generally controlled by frits which are installed in the 3 gas flow channels (2 purge gases, 1 protective gas). Optionally available is a metal-housed mass flow control system (MFC) for purge and protective gases, offering optimum control of the atmosphere around the sample. Well defined gas flow conditions are crucial for accurate interpretation of the measured effects, e.g., to differentiate between oxidation and pyrolysis reactions.

Coupling to Evolved Gas Analysis



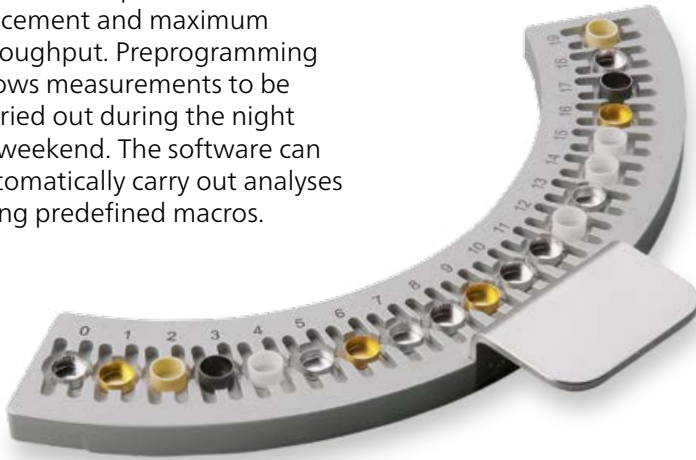
For evolved gas analysis, the system can be coupled to QMS and FT-IR individually or to a combination of QMS and FT-IR – even if equipped with an automatic sample changer – and GC-MS or a combination of FT-IR and GC-MS.



STA 449 **F3 Jupiter**® with automatic sample changer coupled to FT-IR and QMS *Aëolos*®

Automatic Sample Changer

An automatic sample changer for up to 20 samples is optionally available. The sample changer guarantees optimal crucible placement and maximum throughput. Preprogramming allows measurements to be carried out during the night or weekend. The software can automatically carry out analyses using predefined macros.



Accessories

A wide range of crucibles (aluminum, silver, gold, copper, platinum, alumina, zirconia, graphite, stainless steel, etc.) is available for nearly all possible applications and materials.

For working in critical atmospheres, a "corrosive gas version" of the STA 449 **F3 Jupiter**® can be supplied. This version is optimized for measurements under corrosive atmospheres such as reducing.

For measurements on difficult samples or radioactive substances, the STA 449 **F3 Jupiter**® can be prepared for installation in a glove box or hot cell.



*Robust and
Easy-to-Operate*

The STA 449 **F3 Jupiter**[®] runs under the versatile *Proteus*[®] software and includes everything you need to carry out a reliable measurement and evaluate the resulting data – or even carry out complicated analyses. The *Proteus*[®] software is licensed with the instrument and can also be installed on other computer systems. This software is produced by an ISO-certified company.

Please see software features on page 19.

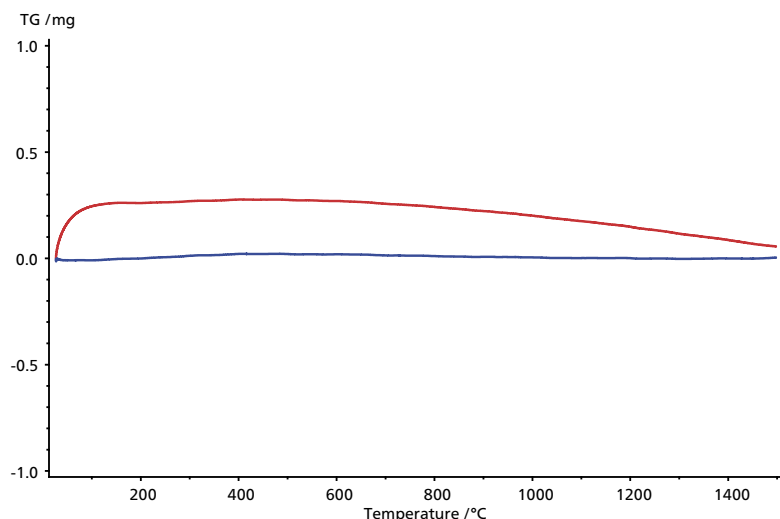
Proteus[®] Software

for the STA 449 **F3 Jupiter**[®]



BeFlat[®] – An Intelligent Way to Save Time

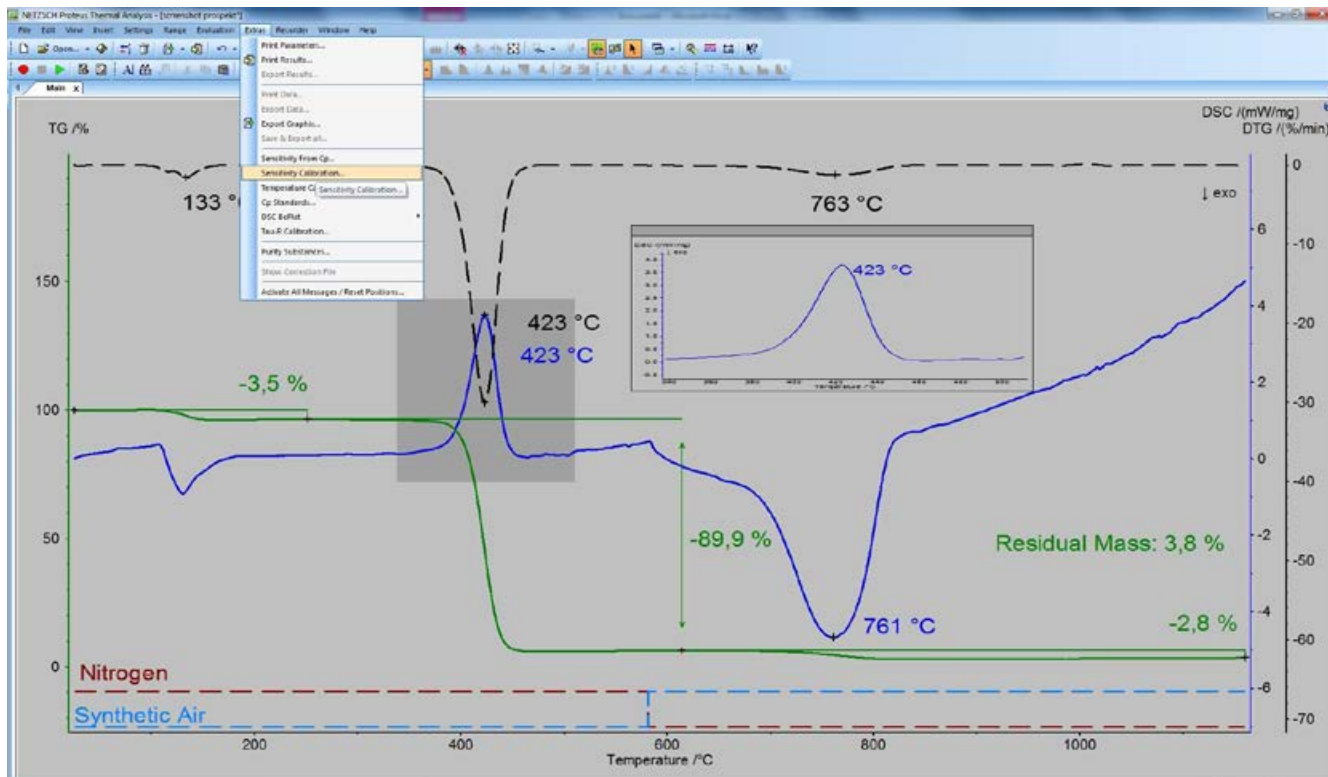
The TGA-*BeFlat*[®] software feature keeps a record of the temperature dependence on the measuring influences, the heating rate, the different purge gases and the gas flow rates, and can therefore provide the appropriate correction for the selected measurement conditions without having to carry out a blank value determination in the form of a correction measurement.



Influence of *BeFlat*[®]: The blue curve represents the TGA measurement with *BeFlat*[®] correction; the red curve, without additional correction. Measurements were carried out on two empty crucibles under identical conditions.

Advanced Software (options)

- *Peak Separation* allows accurate separation and evaluation of overlapping transitions
- NETZSCH *Thermokinetics* allows for advanced characterization of reactions and kinetic parameters on the basis of multiple-step kinetic analysis on up to 16 curves; also provides predictions of the process
- Specific heat capacity determination
- *Purity Determination* via analysis of the DSC melting peak
- *Tau-R*® Mode allows for evaluation of exo/endothermal effects under consideration of time constants and thermal resistance values
- *Thermal Simulations* allows for a description of the decomposition reaction process in order to enable accurate predictions



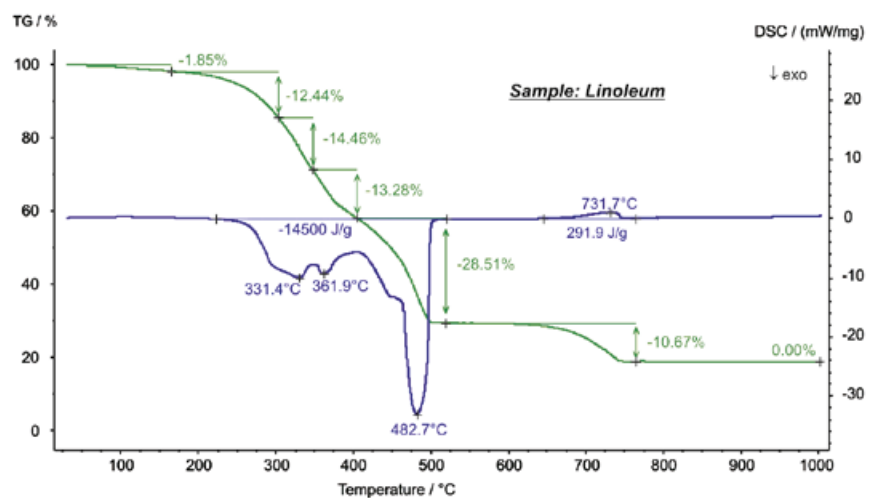
User interface during evaluation: TGA curve (green line) together with the DTG curve (black dotted line), DSC curve (blue line), two curves representing the gas flow of nitrogen (red dotted line) and synthetic air (blue dotted line); PIP presentation (picture-in-picture) for the DSC peak at 423°C.

APPLICATION EXAMPLES

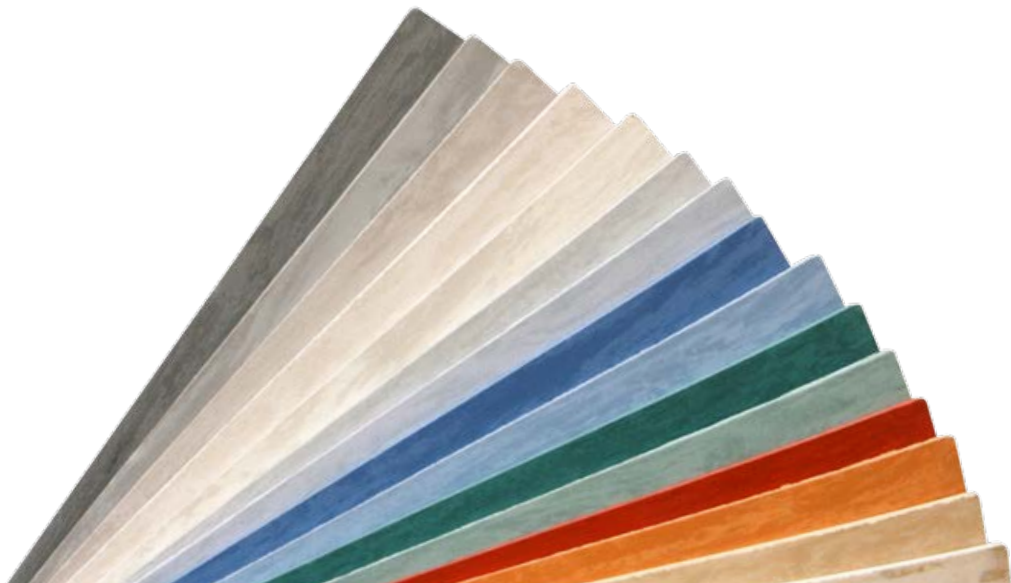
Meaningful Material Characterization *LOW-TEMPERATURE*

Burn-Out of Linoleum

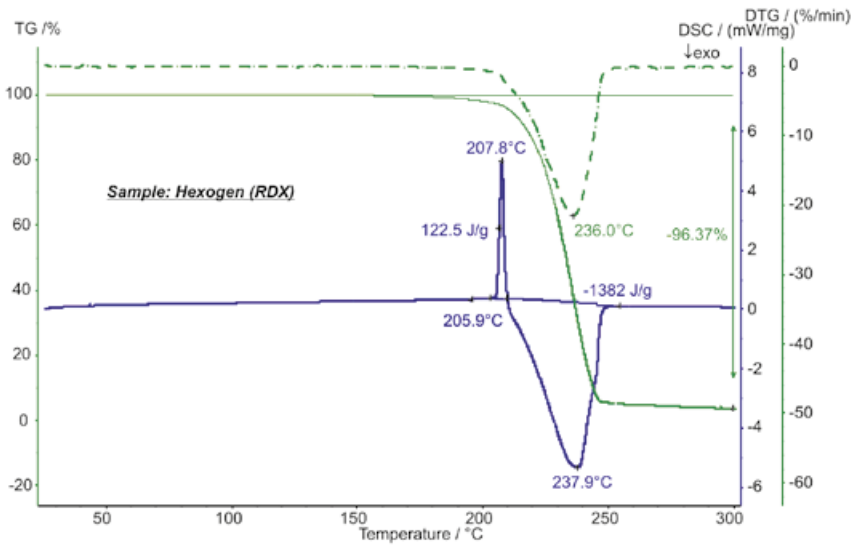
The building material linoleum was invented in 1863 and is most often used as floor covering. It is very robust and has an insulating effect even at small thicknesses. This STA measurement in air reflects the natural contents of linoleum: after the evaporation of humidity below 150°C, the stepwise, strongly exothermic burn-out of linseed oil, natural resins, cork flour, wood flour and the substrate jute followed between approx. 200°C and 500°C. The entire heat released during the oxidation was 14.5 kJ/g. Between 600°C and 750°C, the endothermic decomposition of the filler CaCO_3 (chalk) is observed. Above 750°C, the residual mass remains constant.



The measurement was carried out in the SiC furnace on a linoleum sample (5.52 mg) at a heating rate of 10 K/min in air atmosphere.

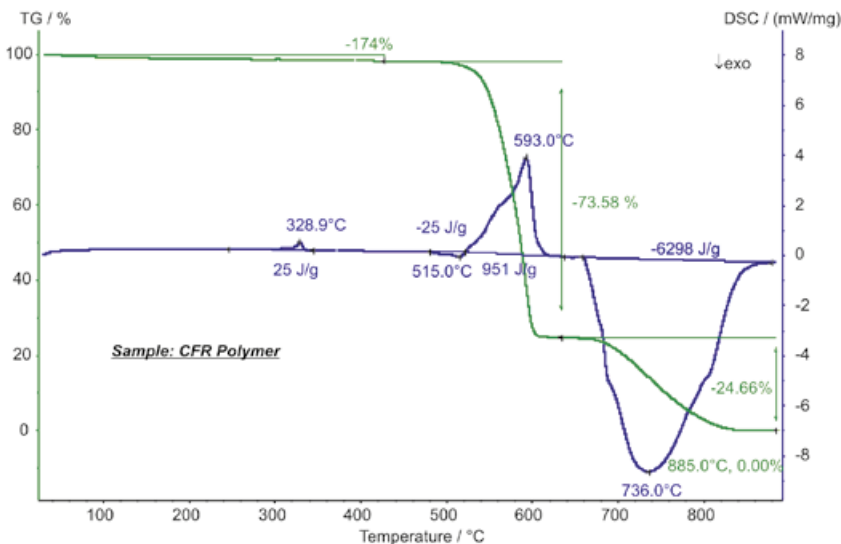


Characterization of Explosives



The hexogen measurement was made in the SiC furnace at a heating rate of 5 K/min in air atmosphere.

The highly explosive material hexogen (also called RDX, T4, etc.) starts to lose mass already at about 150°C, as can be seen from the TGA curve. The endothermic DSC peak at an onset temperature of 206°C with an enthalpy of 123 J/g is due to melting of the sample, followed by a strongly exothermic decomposition, releasing 1.38 kJ/g of energy. This experiment was carried out in a synthetic air atmosphere at a heating rate of 5 K/min using an initial sample mass of only 2.32 mg.



For the measurement on CFRP (7.62 mg) in the SiC furnace, the atmosphere was switched from nitrogen to oxygen at 650°C; heating rate: 10 K/min.

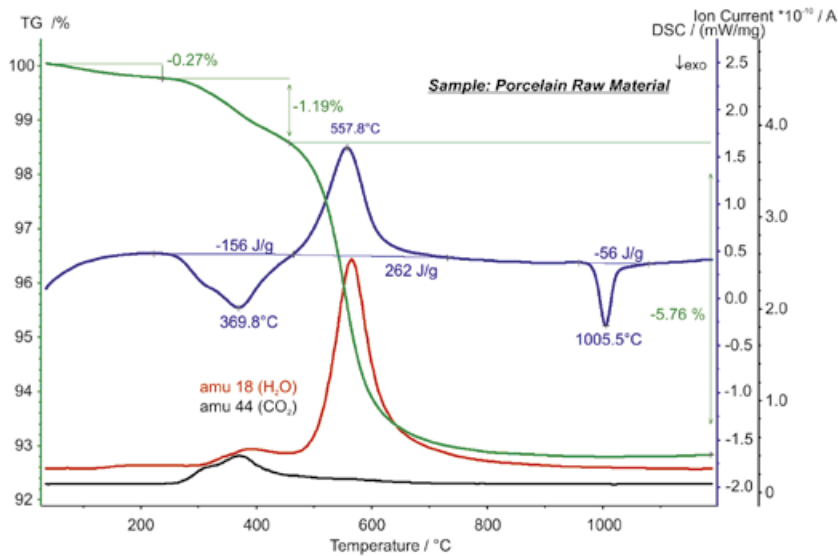
Analysis of Composite Materials

Carbon fiber-reinforced polymers (CFRP) are very popular composite materials which consist of a polymer matrix and embedded carbon fibers. They are suitable for automotive, aircraft and space applications. This STA measurement shows an endothermic DSC peak with an enthalpy of 25 J/g at 329°C which is due to melting of the polymer matrix. Between approx. 480°C and 620°C, the pyrolytic decomposition of the polymer occurred. At 650°C, the purge gas was switched from N₂ to O₂, resulting in the strongly exothermic decomposition of the carbon fiber content (24.7%). The residual mass of 0.0% at the end of the experiment indicates that no further inorganic fillers or glass fibers were in the sample.

Meaningful Material Characterization

HIGH-TEMPERATURE

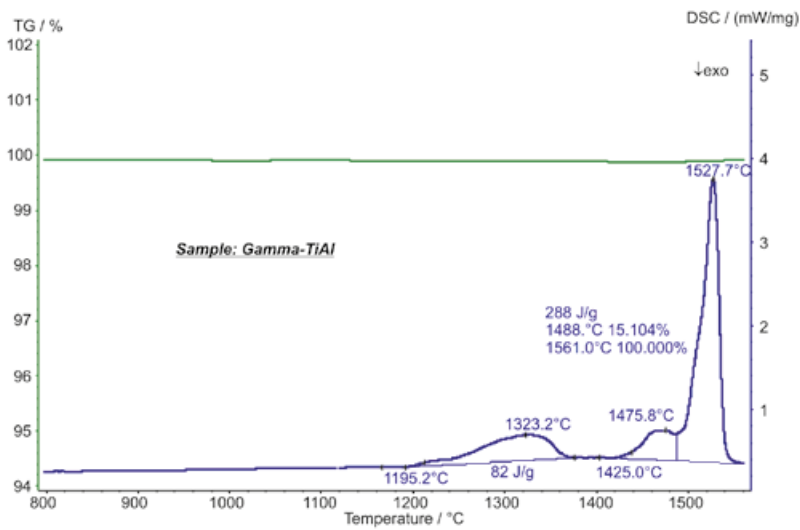
Characterization of Porcelain Raw Material



The porcelain material (37.14 mg) was measured in the SiC furnace in air atmosphere at a heating rate of 20 K/min.

This STA-MS measurement on porcelain raw material shows three mass-loss steps. Below approx. 250°C, the evaporation of humidity occurred. At temperatures between 250°C and 450°C, the burn-out of organic binder was observed, during which 156 J/g of energy was released. The dehydration of kaolin occurred above 450°C and required 262 J/g. The mass spectrometer signals for mass numbers 18 and 44 reflect the corresponding release of H₂O and CO₂. The exothermic DSC peak at 1006°C with an enthalpy of -56 J/g is due to the mullite formation.

Phase Transitions of γ -TiAl

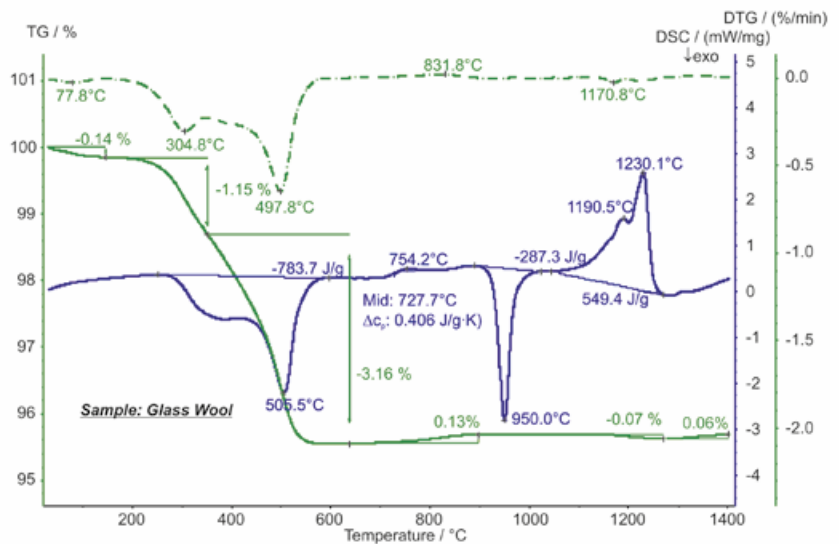


The phase transitions of this metal alloy (32.08 mg) was recorded in the rhodium furnace at a heating rate of 20 K/min to 1600°C in argon atmosphere.

The refractory alloy γ -TiAl distinguishes itself through high temperature and corrosion resistance with a low specific weight. It is used, for instance, in turbochargers and gas turbines. The DSC signal shows an endothermic effect (1323°C peak temperature) beginning at an extrapolated onset temperature of 1195°C; this is due to the structural $\alpha_2 \rightarrow \alpha$ transformation. At 1476°C (DSC peak temperature), the $\alpha \rightarrow \beta$ transformation occurred. The endothermic DSC peak at 1528°C is due to melting of the sample (onset at approx. 1490°C, liquidus temperature at about 1528°C). No significant mass changes were detected during the experiment.

Building Material – Glass Wool

Glass wool is often used for the insulation of houses and heating pipes. The measurement shows three mass-loss steps below approx. 600°C, which are due to the evaporation of humidity and the burn-out of organic binder. The latter can be seen from the strongly exothermic DSC signal in this temperature range. The step in the DSC signal at 728°C is due to the glass transition (increase in the specific heat of 0.41 J/(g·K)). The exothermic DSC peak at 950°C with an enthalpy of -287 J/g is due to crystallization; the endothermic effects between 1050°C and 1250°C with an entire enthalpy of 549 J/g are due to melting. The slight mass changes above 700°C are most probably due to oxidation and evaporation of impurities.



The decomposition of the building material (49.71 mg) was measured in the SiC furnace at a heating rate of 20 K/min in air atmosphere.



STA 449 F3 Jupiter®

Design	Top-loading
Temperature range	-150°C to 2400°C
Furnace	Variety of furnaces incl. high-speed, water-vapor, low to highest temperature, e.g., silver, platinum, tungsten, etc.
Motorized furnace hoist	Double hoist for two furnaces or one furnace + automatic sample changer
Heating rate	<ul style="list-style-type: none"> ▪ 0.001 to 50 K/min (furnace-dependent) ▪ High-speed furnace: up to 1000 K/min
Sensors	TGA, TGA-DTA, TGA-DSC, TGA-DSC _p , special sensors for hanging samples. Sensors can be changed out easily in a matter of moments
Vacuum-tight	10 ⁻⁴ mbar
<i>AutoVac</i>	Option for software-controlled automatic evacuation
Evacuation system	Options for one and two furnaces; manual or software-controlled operation
Atmospheres	Inert, oxidizing, static, dynamic, vacuum
Oxygen trap system (OTS®)	Optional
Automatic sample changer (ASC)	20 crucible positions (optional)
Gas flow control	Integrated frits (optional 3 mass flow controllers)
Temperature resolution	0.001 K
Balance resolution	0.1 µg (over the entire weighing range)
Balance drift	< 5 µg/hour
Maximum sample load	35000 mg (incl. crucible), corresponds to TGA measuring range
Sample volume (max.)	<ul style="list-style-type: none"> ▪ TGA: up to 5 ml ▪ DSC: 0.19 ml ▪ DTA: 0.9 ml
DSC enthalpy accuracy	± 2% (for most materials)
Evolved gas analysis	QMS, GC-MS and/or FT-IR couplings, <i>PulseTA</i> ® (options)
Optional instrument specialties	<ul style="list-style-type: none"> ▪ Glove box version ▪ Corrosion-resistant version

Key Technical Data

Software Features

STA 449 **F3** Jupiter®

Operating systems Windows® operating system

General software features

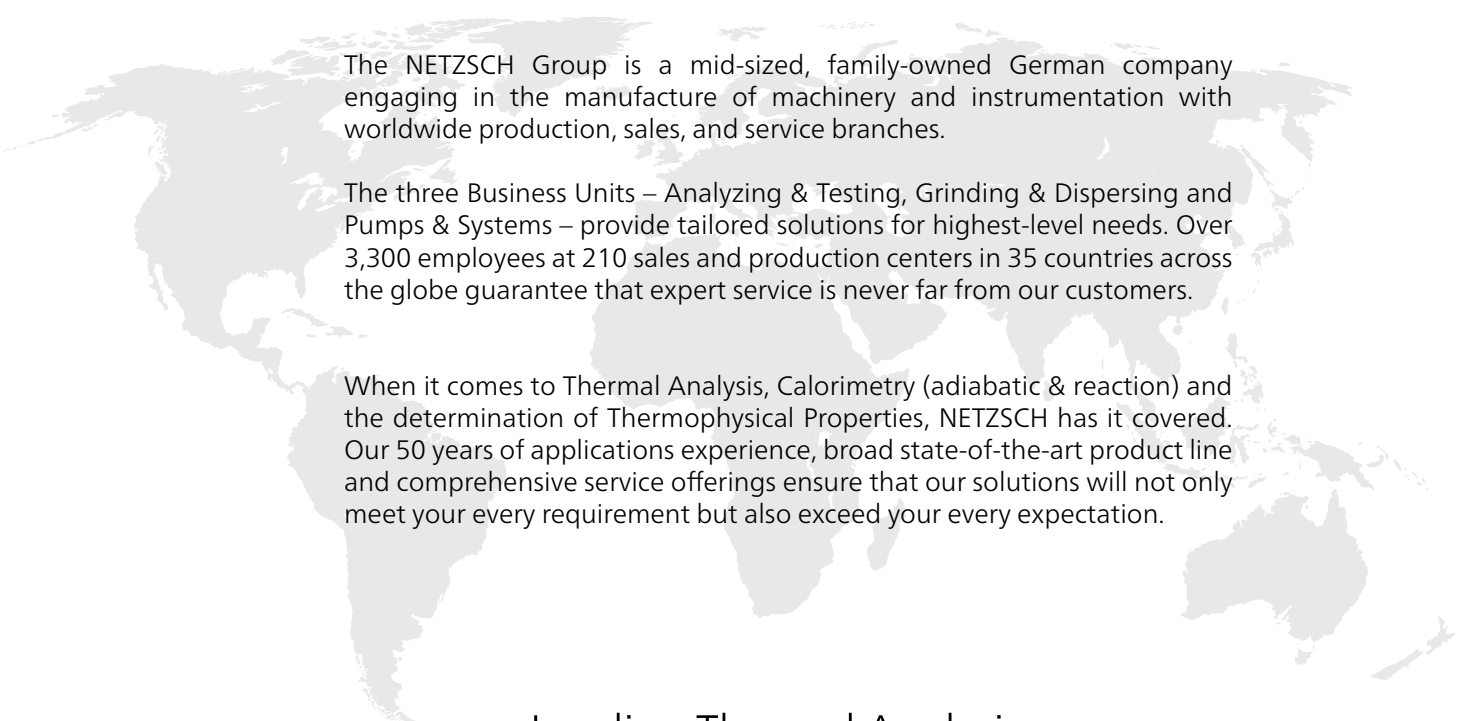
- Multi-tasking: simultaneous measurement and evaluation
- Multi-moduling: operation of different instruments from one computer
- Combined analysis: comparison and/or evaluation of STA, DSC, TGA, DIL, TMA and DMA measurements in one plot
- Selectable scaling
- Graphic and data export
- Calculation of 1st and 2nd derivative including peak temperatures
- Storage and restoration of analyses
- Context-sensitive help system

DSC-specific features

- Determination of onset, peak, inflection and end temperatures, incl. automatic peak search
- Analysis of exothermal and endothermal peak areas (enthalpies) with selectable baseline and partial peak area analysis
- DSC-integral curve
- Comprehensive glass transition analysis
- Degree of crystallinity
- OIT (Oxidative-Induction Time)

TGA-specific features

- Mass changes in % or mg
- Automatic evaluation of mass-change steps including determination of residual mass
- Extrapolated onset and endset
- Automatic TGA-*BeFlat*® baseline correction for automatic correction of measuring influences
- *c-DTA*® for calculation of the DTA signal with evaluation of characteristic temperatures and peak area, optional for TGA measurements
- *Super-Res*® for rate-controlled mass change (optional)



The NETZSCH Group is a mid-sized, family-owned German company engaging in the manufacture of machinery and instrumentation with worldwide production, sales, and service branches.

The three Business Units – Analyzing & Testing, Grinding & Dispersing and Pumps & Systems – provide tailored solutions for highest-level needs. Over 3,300 employees at 210 sales and production centers in 35 countries across the globe guarantee that expert service is never far from our customers.

When it comes to Thermal Analysis, Calorimetry (adiabatic & reaction) and the determination of Thermophysical Properties, NETZSCH has it covered. Our 50 years of applications experience, broad state-of-the-art product line and comprehensive service offerings ensure that our solutions will not only meet your every requirement but also exceed your every expectation.

Leading Thermal Analysis ■

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