

Thermal Analysis Excellence



TGA 2

STAR[®] System

Innovative Technology

Versatile Modularity

Swiss Quality



Thermogravimetry
for Routine Analysis

METTLER TOLEDO

Fast and Accurate TGA Results through seamless workflows

Thermogravimetry (TGA) is a technique that measures the change in weight of a sample as it is heated, cooled or held at constant temperature. Its main use is to characterize materials with regard to their composition. Application areas include plastics, elastomers and thermosets, mineral compounds and ceramics as well as a wide range of analyses in the chemical and pharmaceutical industries.

Features and benefits of the TGA 2:

- **METTLER TOLEDO ultra-micro balance** – rely on the market leader in balance technology
- **High resolution** – sub-microgram resolution over the whole measurement range
- **Robust, factory endurance-tested sample robot** – operate efficiently and reliably around-the-clock
- **Start the experiment with just One Click™** – fast and simple routine operation
- **Built-in gas flow control** – analyse samples in a defined atmosphere
- **Automatic buoyancy compensation** – for faster accurate results
- **Modular concept protects your investment** – fits to your current and future needs
- **Comprehensive services** – professional support for your day-to-day work

TGA with the top-of-the-line METTLER TOLEDO ultra-micro balance with unique built-in calibration weights ensures unbeatable accuracy.



Unique Sensors the Heart of the Instrument

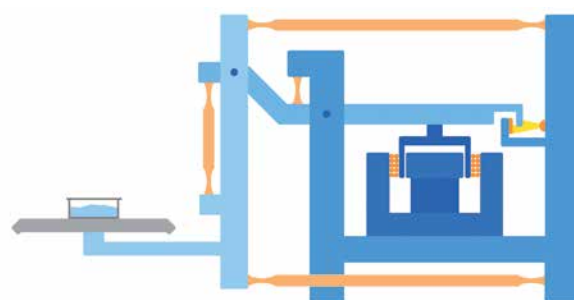


METTLER TOLEDO "Inside"

The heart of a TGA is the balance cell. Our TGA instruments use the world's best METTLER TOLEDO micro and ultra-micro balances. The internal calibration ring weights ensure unsurpassed accuracy. You can also calibrate and adjust your balance with external weights.

Outstanding weighing performance

No other TGA can measure up to 50 million resolution points continuously – weight changes of a 5-gram sample are determined to 0.1 μg . This means you can measure small and large samples with the same high resolution without having to change the weight range.



Ultra microbalance from the market leader

The parallel-guided balance ensures that the position of the sample does not influence the weight measurement. If the position of the sample changes during melting, no change in weight occurs.

Thermostating

The balance cell is thermostated to minimize environmental influences. The cryostat is also used to rapidly cool the furnace.

Balance	Maximum load	Weighing range	Resolution
XP1	1 g	1 g	1.0 μg
XP1U	1 g	1 g	0.1 μg
XP5	5 g	5 g	1.0 μg
XP5U	5 g	5 g	0.1 μg

High Performance Already Built into the Basic Configuration

Horizontal furnace

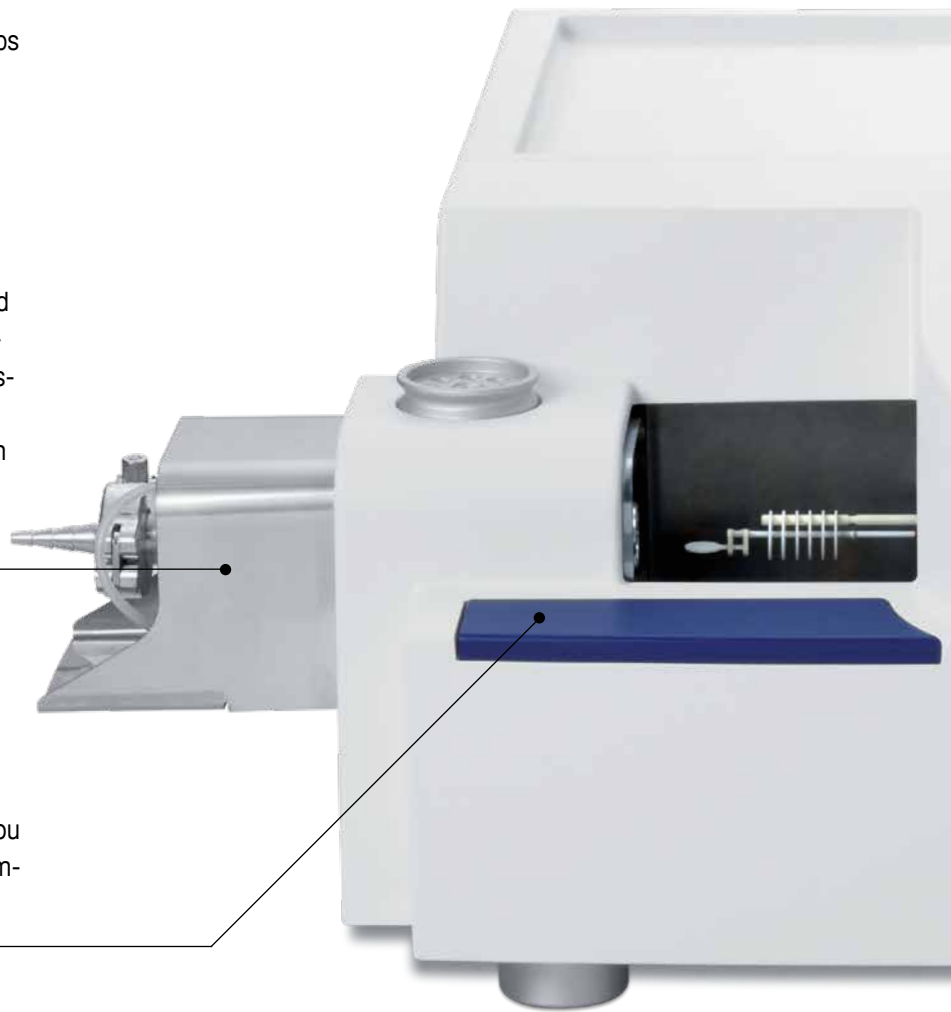
The horizontal furnace design helps minimize possible turbulence caused by thermal buoyancy and the purge gas.

Precisely defined furnace atmosphere

The gastight cell can be evacuated and purged with a defined gas atmosphere. A controlled closed system with precisely defined conditions like this is essential to obtain unambiguous information and quality results.

Ergonomic design

If you insert samples manually, you can rest your hand on an ergonomically shaped support surface.



Valuable application expertise

METTLER TOLEDO offers comprehensive, sector-specific application literature and training options:

- Application handbooks
- UserCom application newsletter
- Application database on the Internet
- Live and on-demand webinars

Application handbooks

www.mt.com/ta-handbooks



Webinars

www.mt.com/ta-webinars





Complete thermal analysis system

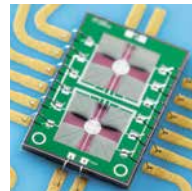
TGA



DSC



Flash DSC



TMA



DMA



A complete thermal analysis system comprises four different techniques. Each technique characterizes the sample in its own particular way. The combination of all the results simplifies interpretation.

TGA measures the weight curve, DSC and Flash DSC the heat flow, TMA the length change, and DMA the modulus.

All these measurement quantities vary as a function of temperature or time.

The powerful **STAR**[®] software allows the user to control all the connected modules and provides unlimited evaluation possibilities.



Important support services

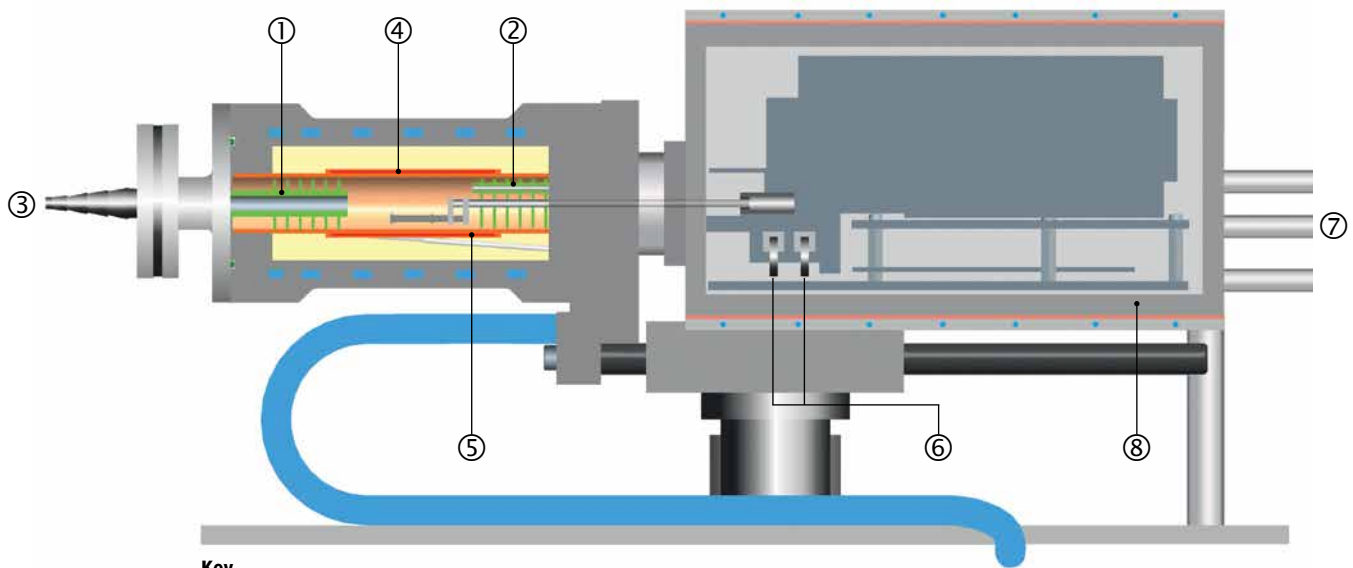
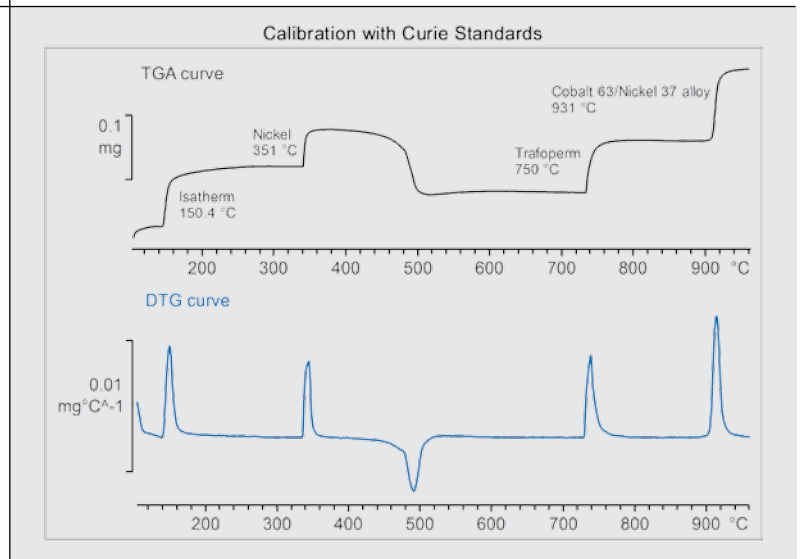
METTLER TOLEDO prides itself in supplying outstanding instruments and the support needed for you to be successful in your field of work. Our well-trained service and sales engineers are ready and available to help you in any way possible:

- Service and maintenance
- Calibration and adjustment
- Training and application advice
- Equipment qualification

Excellent Performance Over the Whole Temperature Range

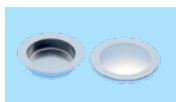
Temperature adjustment with Curie reference substances

The temperature is adjusted using reference substances whose magnetic properties change at defined temperatures (Curie temperatures).



Key

- | | | | |
|--------------------------|------------------|------------------------------|--------------------------------------|
| 1 Baffles | 3 Gas outlet | 5 Furnace temperature sensor | 7 Protective and purge gas connector |
| 2 Reactive gas capillary | 4 Furnace heater | 6 Adjustment ring weights | 8 Thermostated balance chamber |



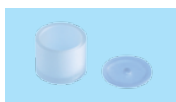
aluminum



alumina

Enormous range of crucibles

We have the right crucible for every application. The crucibles are made of different materials with volumes ranging from 20 to 900 µL. All of the different types can be used with the sample robot.



sapphire



platinum

The crucible brochure and the website at www.mt.com/ta-crucibles provide a comprehensive overview.

Full Automation

Allows Around-the-Clock Operation

The sample robot is very robust and operates reliably 24 hours a day and throughout the whole year.

Automatic and efficient

All TGA 2 models can be automated. The sample robot can process up to 34 samples even if every sample requires a different method and a different crucible.

Fully automatic weigh-in

Samples can be weighed-in semi or fully automatically using the internal TGA balance in combination with the sample robot. You only need an additional balance if you want to measure and weigh-in samples at the same time.

In the first step, all the empty crucibles are automatically weighed. Afterward, you insert a sample in each crucible, repeat the automatic weighing process and you are ready to start. It's that easy. All the samples are then weighed-in fully automatically.



Features and benefits:

- **Up to 34 sample positions** – dramatically increases efficiency
- **Simple and rugged design** – guarantees reliable results
- **Unique “wasp” lid piercing accessory** – hermetically sealed crucibles are automatically opened prior to measurement
- **Universal gripper** – can handle all types of METTLER TOLEDO crucibles



No weight change before measurement

The sample robot can remove the protective crucible lid from the crucible or pierces the lid of hermetically sealed aluminum crucibles immediately before measurement. This unique feature prevents the sample taking up or losing moisture between weighing-in and measurement. It also protects oxygen-sensitive samples from oxidation. The clever design and extra-high crucible lid stop the pin from coming into contact with the sample. This prevents possible contamination of the next sample. You can see the sample changer in action at www.mt.com/ta-automation.

Modularity a Sound Investment for the Future



Furnaces in different sizes

The measurement of inhomogeneous samples requires large sample amounts and correspondingly large sample volumes. The large furnace (LF) allows you to use crucibles with volumes of up to 900 μL .

Hyphenated techniques

All TGA 2 versions can be connected online to a mass spectrometer, an FTIR spectrometer or a GC/MS system. Analysis of the gaseous decomposition products yields additional information about the sample. This enables you to interpret measurement curves with greater certainty. You can find further information in the EGA data sheet and in the TGA-IST16-GC/MS System brochure.

The TGA can also be converted to a TGA Sorption analyzer in just a few minutes.



Interface TGA-MS

Interface Sorption

Designed for the future

You can upgrade from one instrument version to another and add practical accessories any time you like in the future.

Option → required option	Balances				EGA (MS, FTIR, GC/MS)	Sorption	GC 301 gas controller	GC 401 gas controller
	XP1	XP1U	XP5	XP5U				
TGA 2 (SF 1100 °C)	•	•	•	•	•		standard	optional
TGA 2 (LF 1100 °C)	•	•	•	•	•	•	standard	optional
Peripheral control					essential	essential		
Sample Robot	no additional options required							

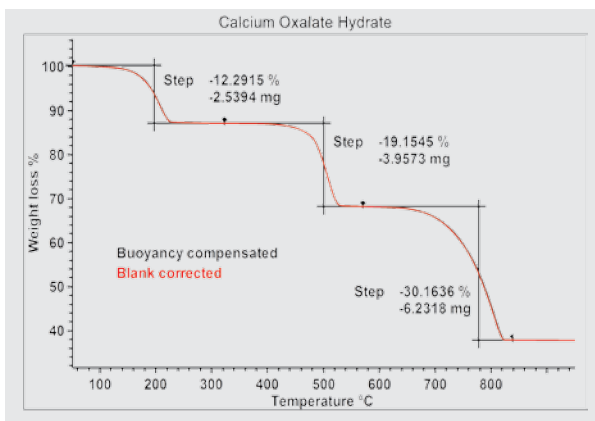
• = selectable

Simple Routine Operation Through Time Saving Solutions



Start routine measurements quickly

The unique One Click™ function allows you to safely and easily start predefined measuring methods directly from the instruments' color touchscreen display. This facilitates the processing of routine measurements by production staff in quality control significantly.



Achieve results faster

The TGA has a new capability to automatically correct for influences on a measurement that are not related to the sample such as buoyancy. This reduces the experimental time needed to produce accurate results by eliminating the need to run a blank measurement. The automatic correction can be switched off by the user. Automatically corrected data are in excellent agreement with blank subtracted data.



Optimal atmosphere

Built-in mass flow controller (MFC) gas supply units and gas delivery close to the sample are a standard feature on the TGA. This allows accurate and repeatable investigation of material properties under a variety of atmospheres and switching of reactive gas during an experiment.

Efficient Sample preparation

The crucible box and toolbox help you keep everything tidy, making sample preparation easier and faster. The calibration box contains all the materials necessary for temperature adjustment. An optional set with certified E2 weights can be used for external weight calibration.



Sample preparation



Weight set

Extremely Wide Application Range

Thermogravimetry provides quantitative information on the composition and thermal stability of many different types of materials. The method is fast and can even be used with very small samples.

The TGA 2 is an exceptionally versatile tool for the characterization of physical and chemical material properties under precisely controlled atmospheric conditions.

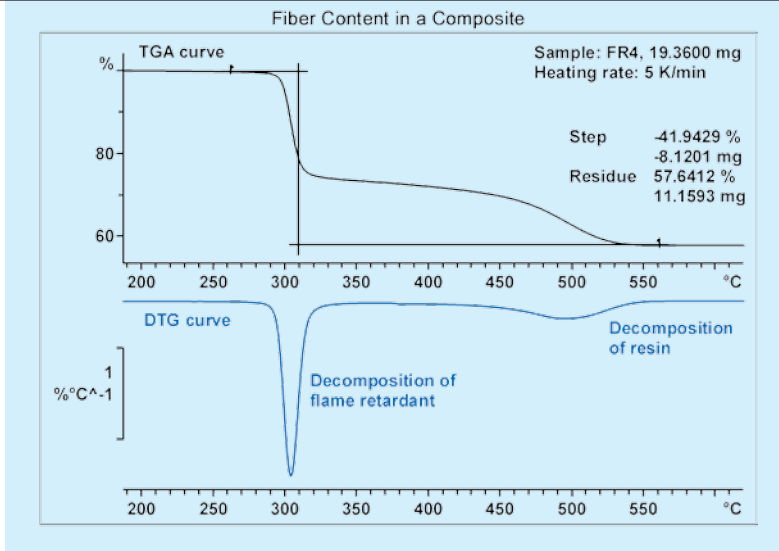


It yields valuable information for research, development and quality control in numerous fields such as plastics, building materials, minerals, pharmaceuticals and food-stuffs.



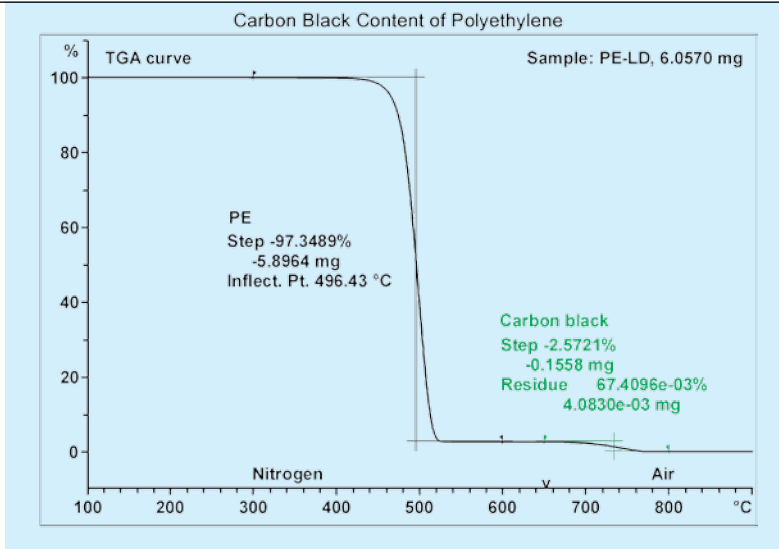
Examples of thermal events and processes that can be determined by TGA

- Quantitative content analysis (moisture, fillers, polymer content, materials, etc.)
- Adsorption and desorption of gases
- Kinetics of decomposition processes
- Sublimation, evaporation and vaporization
- Thermal stability
- Oxidation reactions and oxidation stability
- Identification of decomposition products, solvents and solvates
- Sorption and desorption of moisture
- Pseudopolymorphism
- Determination of Curie temperatures



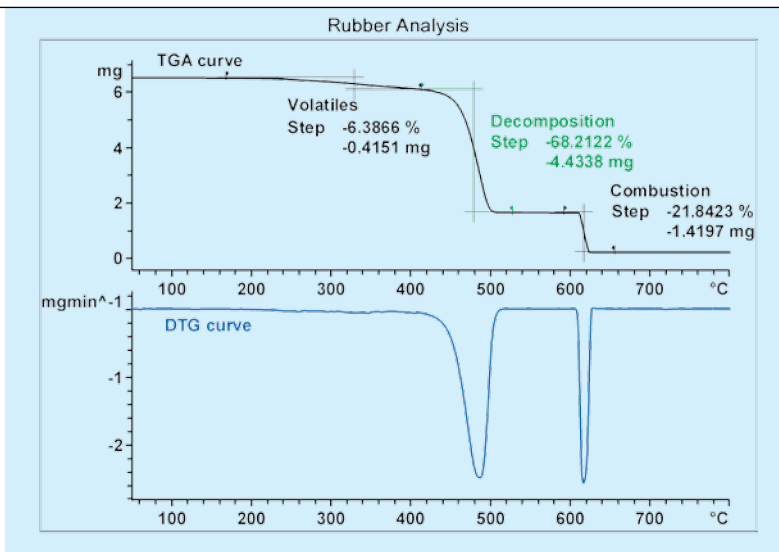
Fiber content in composite materials

Thermosetting materials are often reinforced with fiber materials in order to increase their rigidity. The determination of the fiber content is a regular task in quality control. The measurement shown was performed in air. The first derivative of the TGA curve (DTG) is proportional to the rate of decomposition. The reactions that occur at about 300 °C are responsible for the material's flame resistance. A bromine isotope was identified as a decomposition product using TGA-MS. The rest of the matrix resin burns off in air at temperatures between 450 and 550 °C, leaving behind the glass fabric. Glass fibers made up 57.6% of the sample.



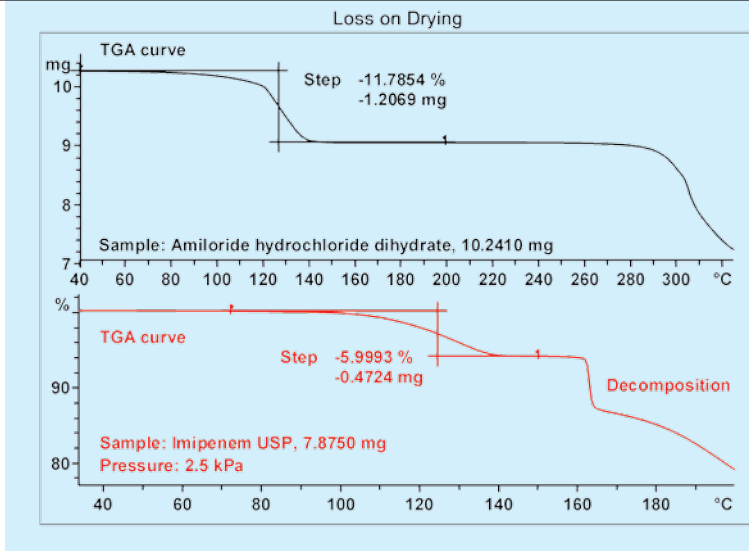
Carbon black content in polyethylene

Polyethylene (PE), the main component, pyrolyzes in a nitrogen atmosphere between 400 °C and 600 °C. The carbon black used as a filler burns off after the atmosphere is switched to air at 650 °C. The higher the specific surface or "activity" of the carbon black, the faster the oxidation reaction takes place. The sample investigated had a polymer content of 97.3% and a carbon black content of about 2.6%.



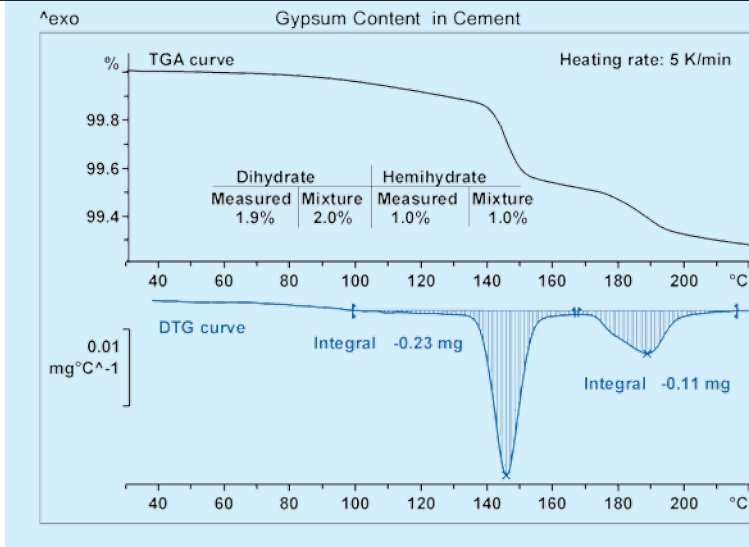
Composition of SBR

In rubber analysis, the sample is first heated to 600 °C under inert conditions. The volatile components (plasticizers, often oils) vaporize and pyrolysis of the polymer begins shortly afterward at about 400 °C. At 600 °C, the atmosphere is then switched from inert to oxidative, resulting in the combustion of the carbon black additive. Inorganic components remain behind as a residue. The SBR sample analyzed in the example contained 6.4% plasticizer, 68.2% polymer and 21.8% carbon black. The residue (mainly zinc oxide) was 3.6%.



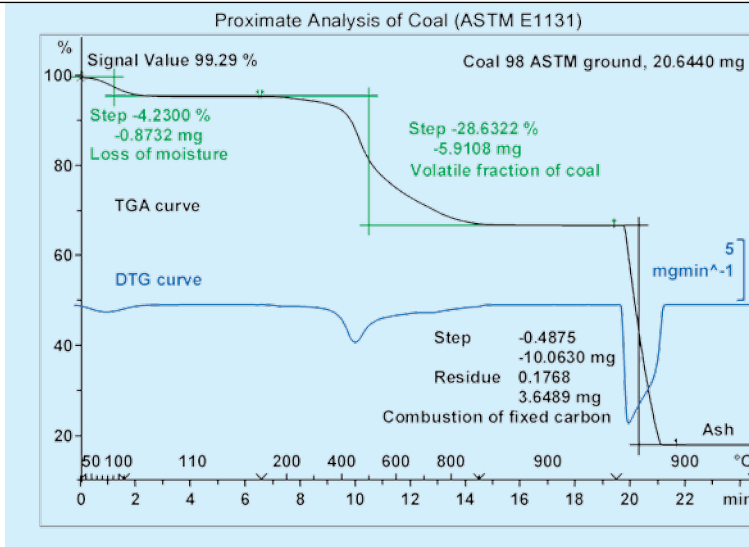
Weight loss on drying

The simplest way to get an overview of the drying behavior of a pharmaceutical substance is to use a standard method, such as the USP "Loss on Drying". The examples show the weight loss curves of amiloride dihydrate (above) and imipenem (below). Imipenem was measured in vacuum at 2.5 kPa. The measurement of the two samples according to the standard method resulted in weight losses of 11.8% and 6% due to the release of water. The weight losses of both substances are within the tolerances permitted in the monographs. Measurements such as these are typically used in control and release analysis.



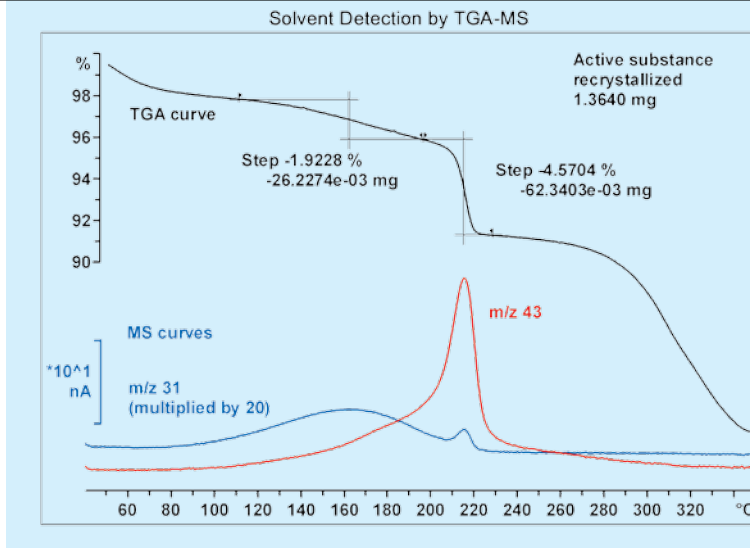
Gypsum content in cement

Gypsum, $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$, is used as a retarder in cement and occurs as the dihydrate and hemihydrate. The two compounds can be analyzed in cement by measuring samples in crucibles sealed with lids with 50- μm holes. The TGA curve shows two weight loss steps corresponding to the dehydration of the gypsum and the hemihydrate. The weight losses are more easily determined by integrating the peaks in the first derivative (DTG) curve. The dihydrate and hemihydrate contents determined in this way agree well with the manufacturer's specifications.



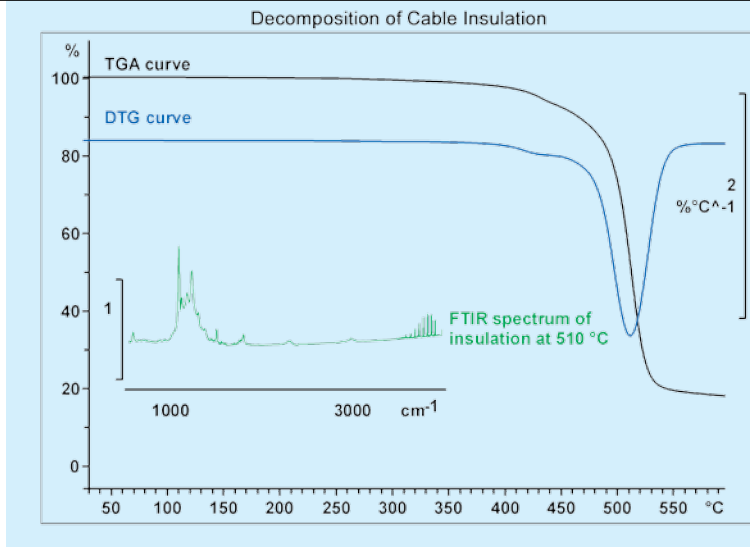
Fast coal analysis

Thermogravimetric analysis provides a convenient way to evaluate the quality of coal and coke in about 20 minutes. The moisture content, volatile substances, bound (fixed) carbon, and ash are all reliably quantified by this method. The higher the ratio of combustible to non-combustible components, the more valuable the coal. In contrast to classical standard methods, the smaller sample sizes and higher heating rates used by the TGA result in significantly faster results. The evaluation shows the analysis of an ASTM standard coal. The measurement is performed in nitrogen up to the first isothermal segment at 900 °C, and then automatically switched to oxygen for the final segment.



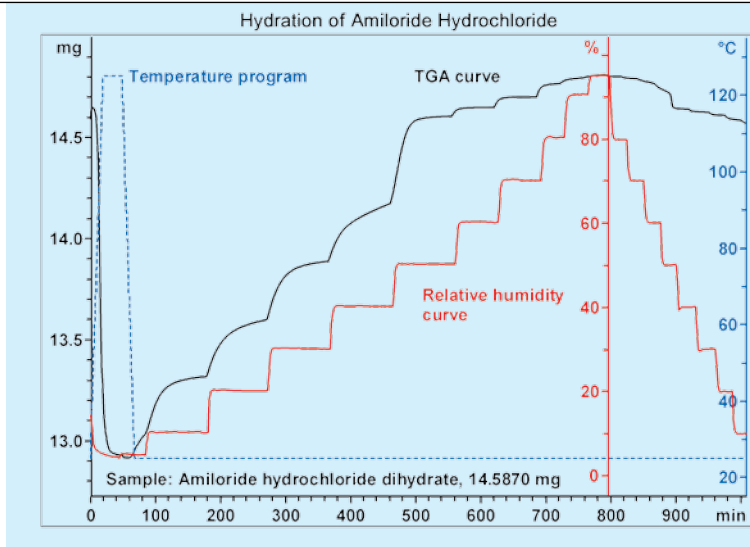
Residual solvents in pharmaceutical substances

Many pharmaceutical substances are recrystallized from solvents. As a result, residues of solvents often remain in the product. Combined techniques such as TGA-MS are ideal to detect and identify such undesired residues. In the example, methanol and acetone were used to recrystallize the active substance. The presence of these two substances is confirmed by the peaks in the m/z 43 and m/z 31 fragment ion curves. The results indicate that the weight loss step at 200 °C is almost entirely due to the elimination of acetone.



Thermal behavior of cable insulation

TGA-FTIR analysis was used to determine whether corrosive substances are formed in the processing of ETFE cable insulation material during thermal treatment. The analysis of finished insulation material indicated that the sample released volatile substances at temperatures above about 275 °C. An IR spectrum recorded during the main decomposition process at 510 °C shows that alkyl fluorides and hydrogen fluoride (HF, 3500 to 4000 cm^{-1}) are produced as decomposition products. HF is therefore released at high temperatures and could potentially attack metal connections. The use of ETFE is, however, perfectly acceptable because processing is performed at lower temperatures.



Dynamic sorption curve

The TGA curve shows the uptake and release of moisture by a sample of amiloride hydrochloride dihydrate as a function of relative humidity (RH). The stages of the analysis include:

- Temperature program with a preconditioning segment (dehydration) at 125 °C (dotted line)
- Increase of RH in steps of 10% with equilibration (red curve)
- Resulting weight changes for each 10% change in RH (black curve)

At a RH of about 50%, the substance has regained its original water of crystallization. Further increase of RH results in the uptake of free surface water. This is liberated when the RH is reduced.

TGA 2 Specifications

Temperature data	Small furnace (SF)	Large furnace (LF)
Temperature range	RT ... 1100 °C	RT ... 1100 °C
Temperature accuracy ¹⁾	±1 K	±1 K
Temperature precision ¹⁾	±0.4 K	±0.6 K
Heating rate ²⁾	0.02 ... 250 K/min	0.02 ... 150 K/min
Cooling time	20 min (1100 ... 100 °C)	22 min (1100 ... 100 °C)
Cooling time with helium ²⁾	≤10 min (1100 ... 100 °C)	≤11 min (1100 ... 100 °C)
Sample volume	≤100 µL	≤900 µL

Special modes		
Automation	optional	
MaxRes		
TGA-MS, TGA-FTIR, TGA-GC/MS		
Vacuum	>10 mbar	>10 mbar
TGA-Sorption	no	optional

Balance data	XP1	XP1U	XP5	XP5U
Measurement range	≤1 g	≤1 g	≤5 g	≤5 g
Resolution	1.0 µg	0.1 µg	1.0 µg	0.1 µg
Weighing accuracy	0.005%	0.005%	0.005%	0.005%
Weighing precision	0.0025%	0.0025%	0.0025%	0.0025%
Repeatability	<0.001 mg	<0.0008 mg	<0.002 mg	<0.0009 mg
Typical Minimum Weight ³⁾	0.19 mg	0.16 mg	0.22 mg	0.17 mg
Typical Minimum Weight USP ^{3) 4)}	1.9 mg	1.6 mg	2.2 mg	1.7 mg
Internal ring weights	2			
Blank curve reproducibility	better than ±10 µg over the whole temperature range			

Dimensions	
Width/depth/height	52/63/28 cm (62.5 cm with sample changer)
Weight	40 kg (44 kg with sample changer)
Power supply	230 V, 60 Hz, 6 A or 115 V, 50 Hz, 12 A

Approvals

IEC/EN61010-1:2001, IEC/EN61010-2-010:2003
 CAN/CSA C22.2 No. 61010-1-04
 UL Std No. 61010A-1
 EN61326-1:2006 (Class B)
 EN61326-1:2006 (industrial environments)
 FCC, Part 15, class A
 AS/NZS CISPR 22, AS/NZS 61000.4.3
 Conformity mark: CE

¹⁾ based on Curie reference substances ³⁾ depends on instrument environment and condition
²⁾ depends on instrument configuration ⁴⁾ USP = United States Pharmacopeia

www.mt.com/tga

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