Thermogravimetric Analysis – TGA
Method, Technique, Applications
Thermo-Microbalance TG 209 **F3 Tarsus**

### TGA Method

Thermogravimetry (TG) or Thermogravimetric Analysis (TGA) is a well proven Thermal Analysis method. TGA is used in the research & development of various substances and engineering materials – solid or liquid – in order to obtain knowledge about their thermal stability and composition.

In recent decades, TGA has been used increasingly for the quality control and assurance of raw materials and incoming goods as well as for failure analysis of finished parts, especially in the polymer processing industry. Various international standards describe the general principles of thermogravimetry for polymers (ISO 11358) or other specific applications, such as compositional analysis for rubber (ASTM D6370) and evaporation loss of lubricating oils (ASTM D6375).

NETZSCH Analyzing & Testing has been manufacturing thermo-microbalances for many years. Our vertical, top-loading design not only provides for easy operation and sample loading, but also allows gases to flow naturally in an upward direction. For evolved gas analyzers (EGA) FT-IR spectrometer can be coupled directly at the top of the unit. The Automatic Sample Changer (ASC) can also be used to conduct routine measurements around the clock.

### Measuring Principle

A thermobalance is used to measure the mass change of a sample as a function of temperature or time, under a defined and controlled environment with respect to heating rate, gas atmosphere, flow rate, crucible type, etc.
The TGA plot shows the decomposition of a high-density polyethylene (HDPE) in a nitrogen atmosphere at a heating rate of 10 K/min. There is only one single mass-loss step representing an almost complete decomposition (residual mass of only 0.8%). The corresponding 1st derivative of the TGA curve, DTGA, provides the decomposition rate. The DTGA peak temperature (478°C) is usually used as a characteristic value to specify the appropriate step. The decomposition products of polyethylene are wax-like. However, modification of the exhaust of the TG 209 F3 Tarsus® (option), specially designed for such applications, also allows investigation of PE on a routine basis.

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**Measurement Result**

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**At a Glance**

- Vertical, top-loading design
- Precise ultra-microbalance
- Gas-tight design with evacuation capability
- Exchangeable sample carrier types
- Automatic Sample Changer (ASC) for up to 20 samples
- Coupling to FT-IR

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TG 209 F3 Tarsus® with automatic sample changer (ASC)
Balance and Furnace Design
The unique top-loading balance guarantees very low drift behavior under isothermal and dynamic measurement conditions over the entire temperature range. A thermostatic control maintains constant temperature and eliminates environmental influences in the balance performance.

Temperature Measurement
The sample temperature is detected by a thermocouple in direct contact with the sample crucible. This ensures an accurate reading of the sample temperature reading and makes it nearly independent from the atmosphere, gas flow or heating rate.

Temperature Calibration
The calculated DTA-signal, c-DTA®, is ideal for easy temperature calibration without the need of a magnet and disassembling the instrument. It also yields important information regarding endothermic and exothermic processes (e.g., melting without mass loss or evaporation with mass loss).

Automatic Sample Changer (ASC)
An ASC for up to 20 samples is available. The software includes a macro recorder for automatic sample definition, evaluation of the measurements and evaluation control.

Sample Holders
Various sample carriers are available including corrosion-resistant sensors, high-sensitivity c-DTA® sensors for improved monitoring of endo- and exothermic effects, and special sensors for large sample masses.

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**Technical Key Data for the TG 209 F3 Tarsus®**

<table>
<thead>
<tr>
<th>Design</th>
<th>Top-loading, vertical</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature range</td>
<td>RT to 1000°C</td>
</tr>
<tr>
<td>Heating rate</td>
<td>0.001 K/min to 100 K/min</td>
</tr>
<tr>
<td>Cooling time</td>
<td>25 min</td>
</tr>
<tr>
<td>Max. sample weight/measuring range</td>
<td>2 g</td>
</tr>
<tr>
<td>Resolution</td>
<td>0.1 µg</td>
</tr>
<tr>
<td>Sample holder systems</td>
<td>High sensitivity (c-DTA®)</td>
</tr>
<tr>
<td></td>
<td>Corrosion-resistant</td>
</tr>
<tr>
<td></td>
<td>High volume/large masses</td>
</tr>
<tr>
<td>Gas atmospheres</td>
<td>Inert, oxidizing, static and dynamic</td>
</tr>
<tr>
<td>Temperature calibration</td>
<td>Options</td>
</tr>
<tr>
<td></td>
<td>c-DTA®</td>
</tr>
<tr>
<td></td>
<td>Curie standards</td>
</tr>
<tr>
<td>Automatic sample changer (ASC)</td>
<td>20 positions, different crucibles types</td>
</tr>
</tbody>
</table>
Crucible Types for Various Applications¹, ²

<table>
<thead>
<tr>
<th>Application</th>
<th>Material</th>
<th>Diameter/Height</th>
<th>Volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard TGA tests</td>
<td>Al₂O₃</td>
<td>6.8 mm/4 mm</td>
<td>85 µl</td>
</tr>
<tr>
<td>Standard TGA tests, high sample input</td>
<td>Al₂O₃</td>
<td>8.0 mm/8 mm</td>
<td>300 µl</td>
</tr>
<tr>
<td>Standard TGA tests, higher sample input</td>
<td>Al₂O₃</td>
<td>9.0 mm/7 mm</td>
<td>350 µl</td>
</tr>
<tr>
<td>Especially for c-DTA®</td>
<td>Pt/Rh (80/20)</td>
<td>6.8 mm/2.7 mm</td>
<td>85 µl</td>
</tr>
<tr>
<td>Especially for c-DTA®, high volume</td>
<td>Pt/Rh (80/20)</td>
<td>6.8 mm/6 mm</td>
<td>190 µl</td>
</tr>
<tr>
<td>Especially for c-DTA®, up to max. 600°C</td>
<td>Al (99.5 %)</td>
<td>6.7 mm/2.7 mm</td>
<td>85 µl</td>
</tr>
</tbody>
</table>

¹ More crucibles available in other materials
² Please note crucible-sample compatibility

Exchangeable Sample Carrier Types³

<table>
<thead>
<tr>
<th>Application</th>
<th>Material of the sample support</th>
<th>Sensor type</th>
<th>For crucible types</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard TGA</td>
<td>Al₂O₃</td>
<td>Type P</td>
<td>7 mm to 9 mm Ø, 85 µl to 350 µl</td>
</tr>
<tr>
<td>Ideal for c-DTA®</td>
<td>PdPt/Au/AuPd (Platinel®)</td>
<td>Type P (disk)</td>
<td>7 mm to 9 mm Ø, 85 µl to 350 µl</td>
</tr>
<tr>
<td>For corrosive media</td>
<td>Al₂O₃</td>
<td>Type P, protected</td>
<td>7 mm to 9 mm Ø, 85 µl to 350 µl</td>
</tr>
</tbody>
</table>

³ For ASC: max. diameter of the crucible is 8 mm
Proteus® Software for TG 209 F3 Tarsus® –
Highly Efficient and User-Optimized

The TG 209 F3 Tarsus® runs under the versatile Proteus® software on a Windows® operating system. The Proteus® software 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.

General Software Features
- Multi-tasking for simultaneous measurement and evaluation
- Multi-moduling for up to 4 different instruments
- Multi-method analysis for curve comparison and evaluation of various methods
- Snapshot for on-line evaluation of the running measurement
- Picture-in-picture presentation (PIP and FLIP)
- Graphic and data export
- Storage and restoration of analyses
- Context-sensitive help system
- Macro recorder

Main TGA Features
- Mass change in % or mg
- Automatic evaluation of mass change steps and characteristic temperatures
- Extrapolated onset and end-point
- Peak temperatures and values of the 1st and 2nd derivatives
- Multi-point temperature calibration via c-DTA®; calculated DTA (option)
- c-DTA® for evaluation of endothermal and exothermal effects (option)
- Super-Res® (rate-controlled mass change) for improved resolution and separation of superimposed mass changes (option)
- Value determination on a single curve or a curve family
- Curve subtraction of baselines and sample runs

Advanced Software Packages (optional)
- Peak Separation for mathematical separation of DTGA peaks which are in close proximity
- Thermokinetics for kinetic analysis of measurement data in order to predict the stability or decomposition behavior of materials by using freely selectable time/temperature programs
User Interface of the Proteus® software during evaluation:

In the main frame, the measured and calculated curves (TGA – highlighted in white, DTGA – green, dashed, temperature – black, dashed and gas flow – red, dash-dotted) are visible; on the left side, the user can find more information about the presented signals and specific curves.
Meaningful Material Characterization

Application Fields

The TG 209 F3 Tarsus® can be employed for the characterization of a great variety of materials and applications including polymers, pharmaceuticals, textiles, foods, cosmetics, and other organic and inorganic materials. For researchers in fields such as automotive, pharmaceuticals, textiles, etc., the technique employed by this instrument is a fast and reliable research tool. Its easy operation, fast analysis time and standardized evaluation procedures make the TG 209 F3 Tarsus® ideal for application in quality assurance and failure analysis.

Components of Glass Fiber Reinforced Polyamide

This PA66/GF sample was heated to 850°C in an inert gas atmosphere at 20 K/min. Already between 70°C and 250°C, a considerable mass loss of 0.6% is determined (picture-in-picture presentation). Decomposition (63.4%) starts at approx. 360°C with a maximum decomposition rate at 455°C (DTG peak). After switching to an oxidizing atmosphere at 850°C, the pyrolysis carbon is burnt (1.5%). The remaining residue corresponds to the glass fiber amount (34.5%).

Picture-in-Picture plot of the TGA measurement on PA66/GF
Decomposition of a Sample from a Modified Rigid PVC-U Profile

The decomposition of a PVC sample can be followed by means of a TGA measurement in nitrogen atmosphere. The plot shows several mass-loss steps between room temperature and 600°C. The first three mass changes (with the main DTGA peak at 311°C) are due to the release of chlorinated components. The subsequent cracking of the hydrocarbon backbone can be observed at 474°C (DTGA peak). The residue of 19.9% at 600°C can be attributed to an inorganic filler.
Expertise in Service

Our Expertise – Service

All over the world, the name NETZSCH stands for comprehensive support and expert, reliable service, before and after sale. Our qualified personnel from the technical service and application departments are always available for consultation.

In special training programs tailored for you and your employees, you will learn to tap the full potential of your instrument.

To maintain and protect your investment, you will be accompanied by our experienced service team over the entire life span of your instrument.

Summary of Our Services

- Installation and commissioning
- Hotline service
- Preventive maintenance
- Calibration service
- IQ / OQ / PQ
- On-site repairs with emergency service for NETZSCH components
- Moving / exchange service
- Technical information service
- Spare parts assistance
Our Expertise – Applications Laboratories

The NETZSCH Thermal Analysis applications laboratories are a proficient partner for nearly any Thermal Analysis issue. Our involvement in your projects begins with proper sample preparation and continues through meticulous examination and interpretation of the measurement results. Our diverse methods and over 30 different state-of-the-art measuring stations will provide ready-made solutions for all your thermal needs.

Within the realm of thermal analysis and the measurement of thermo-physical properties, we offer you a comprehensive line of the most diverse analysis techniques for materials characterization (solids, powders and liquids).

Measurements can be carried out on samples of the most varied of geometries and configurations. You will receive high-precision measurement results and valuable interpretations from us in the shortest possible time. This will enable you to precisely characterize new materials and components before actual deployment, minimize risks of failure, and gain decisive advantages over your competitors.

For production problems, we can work with you to analyze concerns and develop solutions. The minimal investment in our testing and services will reward you with reduced down time and reject rates, helping you optimize your processes across the board.
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 3,000 employees at 163 sales and production centers in 28 countries across the globe guarantee that expert service is never far from our customers.

When it comes to Thermal Analysis, Adiabatic Reaction Calorimetry 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.