Thermal Analysis Excellence

DSC 3

STAR^{e} System

Innovative Technology

Versatile Modularity

Swiss Quality

Differential Scanning Calorimetry

For Routine Analysis

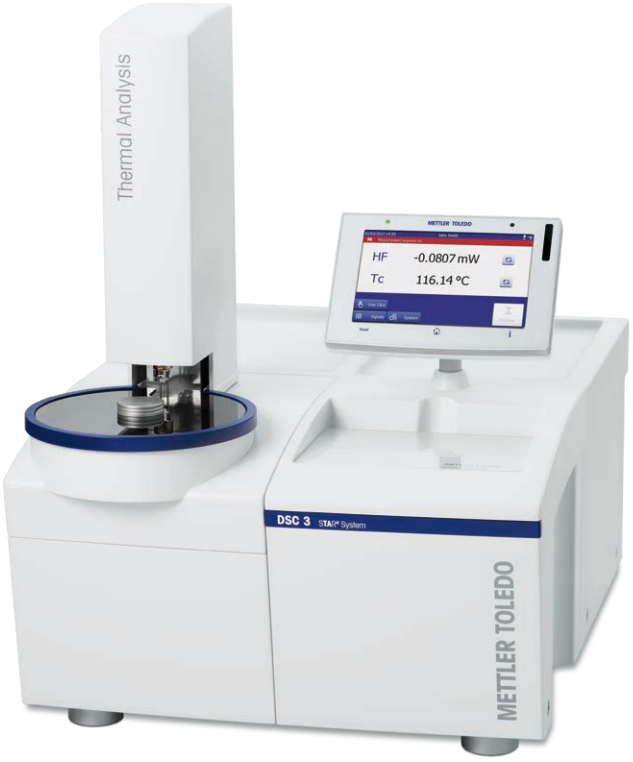
METTLER TOLEDO

Unmatched DSC Performance
Tailored Exactly to Your Needs

Differential scanning calorimetry (DSC) is the most frequently used thermal analysis technique. DSC measures enthalpy changes in samples due to changes in their physical and chemical properties as a function of temperature or time.

Features and benefits of the METTLER TOLEDO DSC 3:

- **Rugged MultiSTAR^{e} sensor with 56 thermocouples** – detects the smallest and largest thermal effects
- **Robust endurance-tested sample robot** – operates efficiently and reliably around the clock
- **Start the experiment with just OneClick™** – fast and easy routine operation
- **Simple FlexCal™ calibration** – saves time and results in precise and accurate measurements
- **Modular concept protects your investment** – fulfills your current and future needs
- **Wide temperature range** – from –150 to 700 °C in one measurement
- **Intelligent ergonomic design** – simplifies instrument operation
- **Comprehensive services** – professional support for your daily work



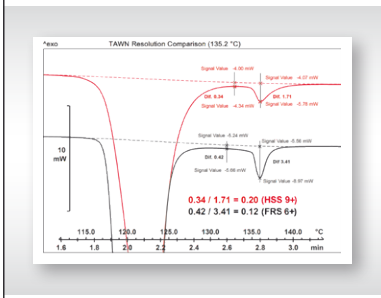
The DSC uses robust and versatile DSC sensors with 56 (FRS) or 120 (HSS) thermocouples which guarantee outstanding resolution and sensitivity.

www.mt.com/ta-dsc

Breakthrough in DSC Sensor Technology
Unsurpassed Sensitivity and Resolution

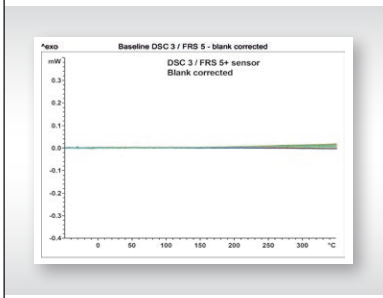
Don't make any compromises concerning the sensor, the heart of your DSC. The METTLER TOLEDO MultiSTAR™ sensors successfully combine a number of important characteristics that are unattainable with conventional sensors and that until now have been impossible to achieve. These included high sensitivity, excellent temperature resolution, a perfectly flat baseline and robustness.

Temperature resolution



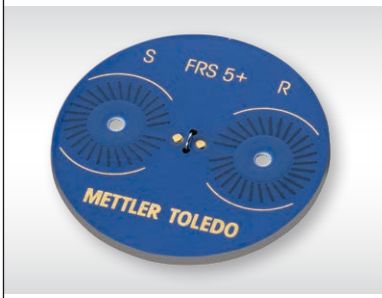
The signal time constant determines how well close-lying or overlapping thermal effects are separated from one another. Our ceramic sensor material provides excellent performance due its low thermal mass and high thermal conductivity.

Baseline



Our revolutionary star-shaped arrangement of thermocouples around the sample and reference crucibles completely compensates any possible temperature gradients. This guarantees flat baselines and reproducible measurement results.

Robustness



The Full Range FRS 5+ sensor has 56 thermocouples and thanks to its ceramic surface it is robust and chemically resistant making it ideal for daily use.

The ceramic-coated surface protects the sensor against chemical attack and contamination. This ensures long lifetime and constant performance characteristics throughout the entire temperature range.

www.mt.com/ta-sampleprep

Swiss Quality

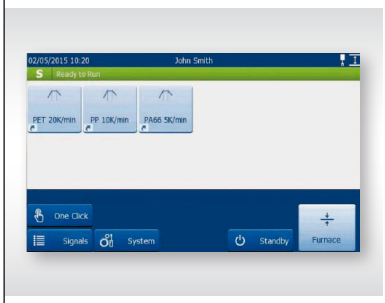
DSC 3 from METTLER TOLEDO
The Right Decision

The DSC 3 has a modular design, making it an ideal choice for automatic or manual operation, from industrial development and academic research to production and quality assurance.

SmartSens terminal

If the DSC is not installed next to a PC running the STARe software, you can set up individual sequences directly at the instrument terminal. The adaptable and intuitive touchscreen or SmartSens allows you to switch screens or open the furnace handsfree.

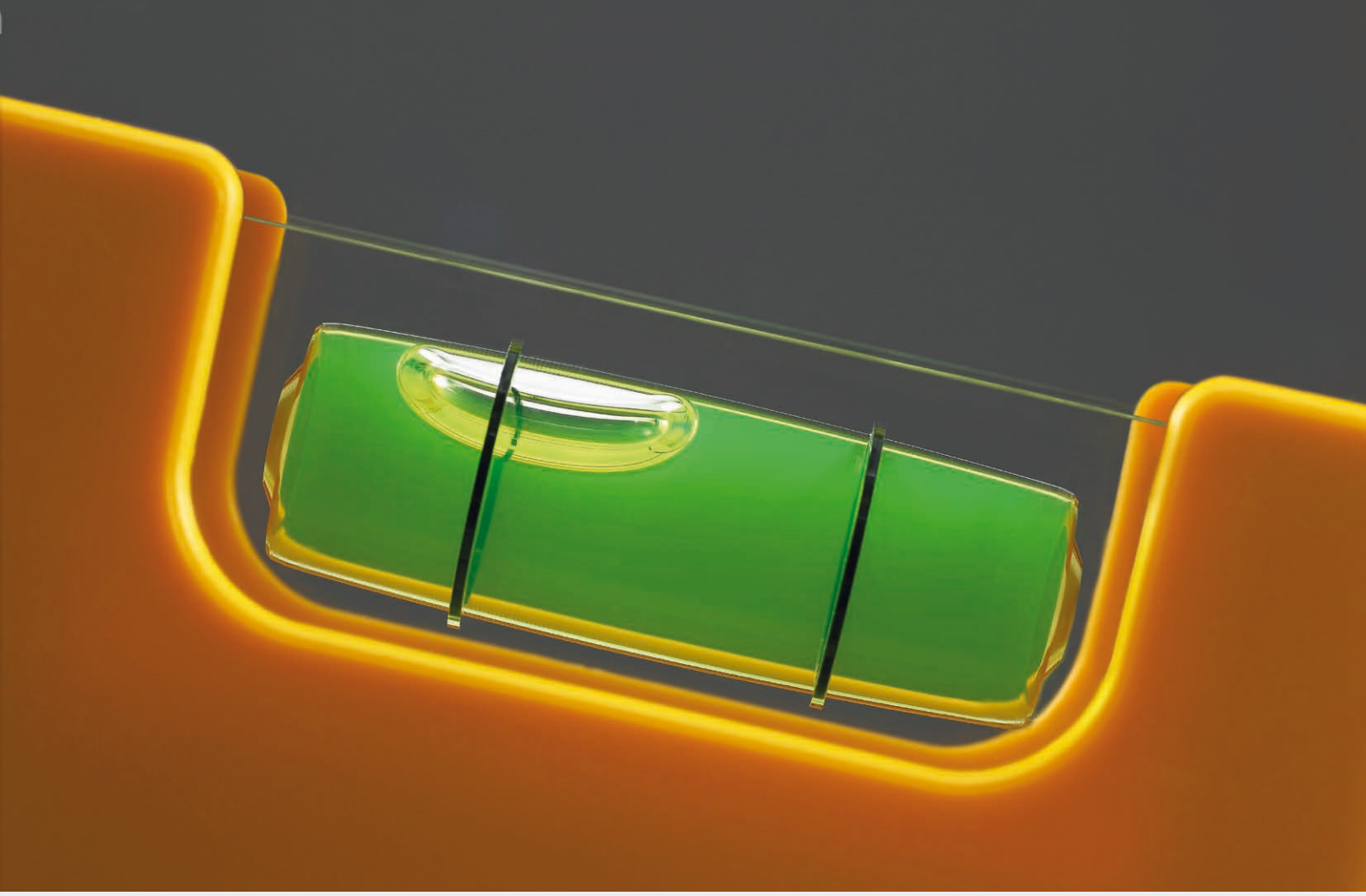
OneClick™ function



The terminal with the OneClick function is clearly visible even at a distance and provides information on the status of the measurement. The OneClick function allows you to easily and efficiently start a predefined method.

Ergonomics in perfection

The ergonomic design has been improved: If you insert samples manually, you can rest your hand on an ergonomically shaped support surface.



FlexCal™ – automatically applies the correct adjustment parameters

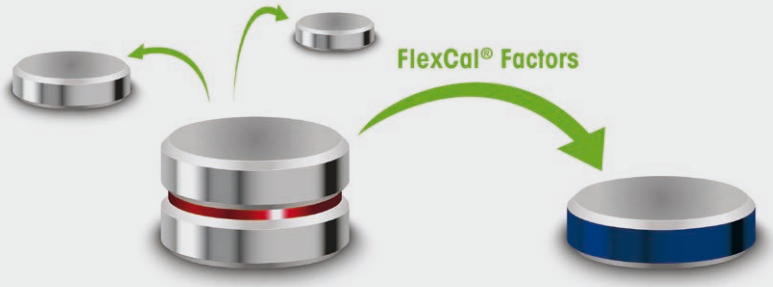
FlexCal offers two benefits:

a) FlexCal database: STARe software stores the complete adjustment data in the database for every crucible, gas and module combination.

b) FlexCal factors: For the case that there is no specific adjustment data available, the system takes a base adjustment dataset and calculates a dataset for another crucible, gas and module combination.

a

b



Calibration is key at METTLER TOLEDO. Benefit from our unique calibration and adjustment services for your thermal analysis instrumentation:

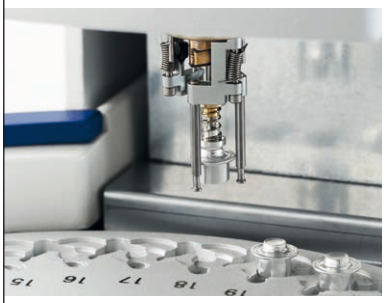
- Professional adjustment by supplier-trained experts – improves result accuracy
- Supplier certificates – in accordance with regulatory requirements

www.mt.com/ta-calibration

Reliable Automation
24 Hours a Day, Like a Swiss Watch

Automatic and efficient, our sample robot is a sophisticated automation option allowing for reliable operation 24 hours a day though the whole year. Together with the STAR^{e} software, the power of the automation is increased by our unique FlexCal™ calibration concept always selecting the correct adjustment parameters, and the possibility to automatically evaluate results.

Unique lid piercing accessory



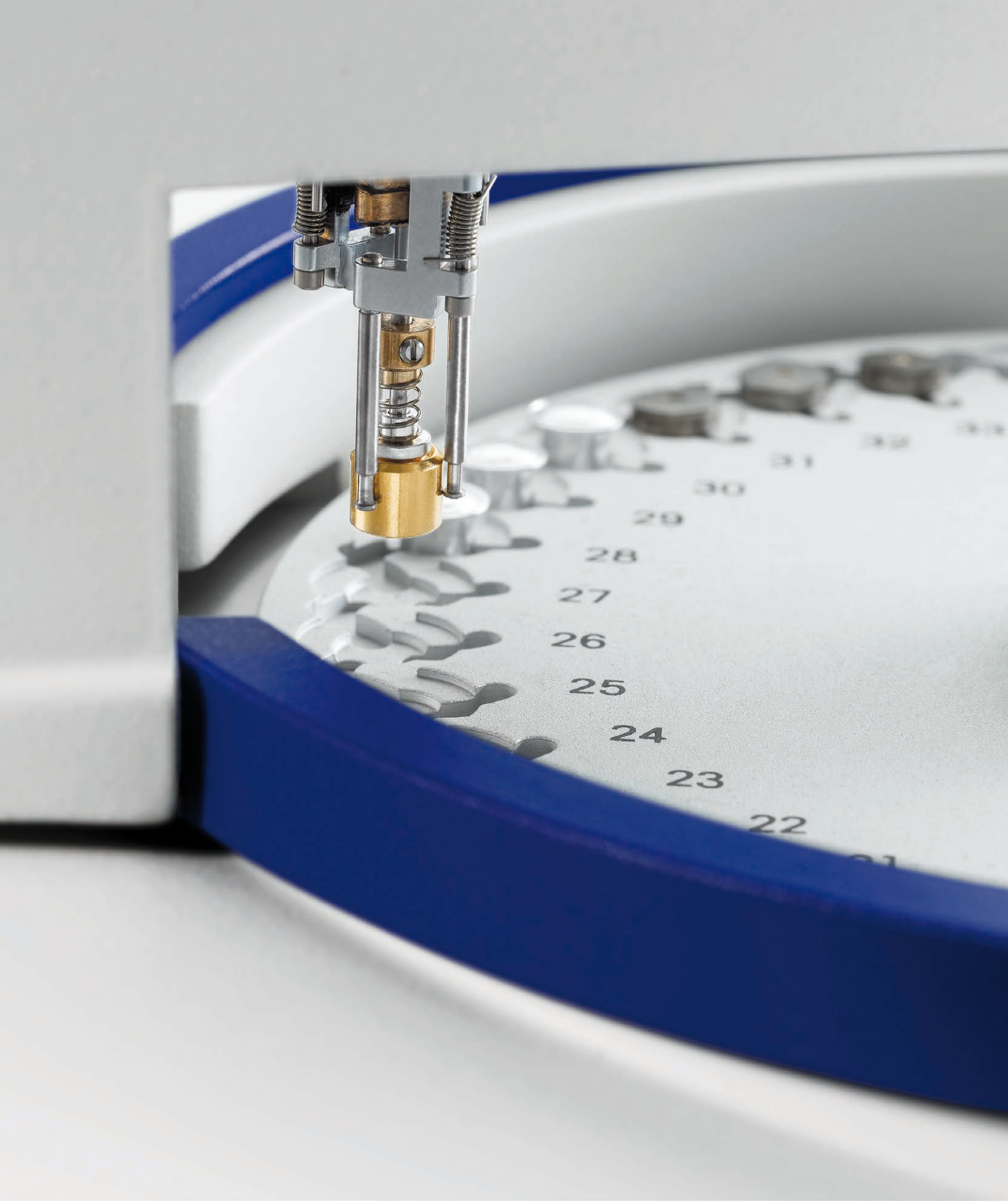
The sample robot can remove the protective crucible lid from the crucible or can pierce the lid of hermetically sealed aluminum crucibles immediately before measurement. This unique feature prevents the sample from taking up or losing moisture between weighing-in and measurement. It also protects oxygen-sensitive samples from oxidation.

Automatic furnace lid

The automatic furnace lid opens and closes the furnace chamber at a keystroke or when actuated by the SmartSens infrared sensors. Manual removal and replacement of the furnace lid is no longer necessary. The measurement cell is effectively isolated from the environment thanks to its optimized design with three superimposed silver lids and its heat shield.

Universal gripper

The universal gripper can handle all types of METTLER TOLEDO crucibles.



All our DSC models can be automated. The sample robot can process up to 34 samples even if every sample requires a different method or a distinct crucible.

www.mt.com/ta-automation

Innovative Accessories
Increases Measurement Power

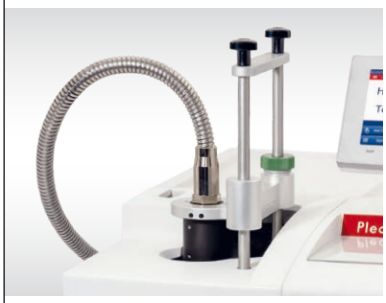
A DSC instrument can be easily equipped with an optical accessory, such as a microscope or photocalorimeter. DSC microscopy allows the user to capture images of the sample while it is heated or cooled in the DSC. DSC Photocalorimetry exposes a sample to light of a particular wavelength range and intensity for a defined time and records the heat flow from the sample.

DSC microscopy

DSC curves often exhibit effects that cannot immediately be explained. In such cases, it is often helpful to visualize the changes in the sample directly by means of microscopy. The versatile optical accessory can be used with any METTLER TOLEDO DSC. It consists of an optical system, a CCD camera, and image capture and processing software.

www.mt.com/ta-optics

DSC photocalorimetry



The photocalorimetry accessory for the DSC allows you to characterize UV curing systems. You can study photoinduced curing reactions and measure the effects of exposure time, UV light intensity and temperature on material properties.

Light sources for UV measurements

Different types of light sources:

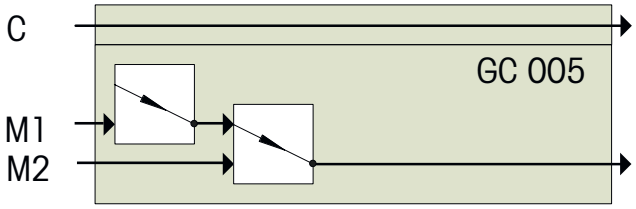
- Light source with a wavelength range (in the UV light)
- Light source with a wavelength range (in the VIS light)
- Light sources based on LED technology (provided wavelengths: 365, 385 or 400 nm)

Option Matrix: A DSC 3 for every need and configuration can be found in the below table.

Option → required option	FRS 5+	HSS 8+	Automatic furnace lid	SmartSens terminal	Peripheral control	Switched line socket	GC 302 GC 402	Air cooling	Cryostat	Intra-Cooler	Liquid nitrogen
DSC 3 (500 °C)	•	•	optional	optional				•	•	•	•
DSC 3 (700 °C)	•	•	optional	optional				•	•	•	•
Sample changer (34)			essential	essential							
Automatic furnace lid				essential							
Gas controller (GC 302)				recom.			optional				
Gas flow-switch (GC 005)				optional			optional				
Cryostat/IntraCooler						optional (recom.)					

● = Selectable

Upgrading your system is possible in the future. The modularity of the system lets you buy today and improve it tomorrow. Adding practical accessories or changing the furnace is possible at any time.



Defined furnace atmosphere, programmable gas flow and gas switching

The furnace chamber can be purged with a defined gas. This process is software controlled, which makes it very easy to switch from an inert atmosphere to reactive conditions.

Air cooling	RT to 500 °C / 700 °C
Cryostat cooling	–50 to 450 °C / 700 °C
IntraCoolers (several)	–35 to 450 °C / 700 °C –85 to 450 °C / 700 °C –100 to 450 °C / 550 °C
Liquid nitrogen cooling	–150 to 500 °C / 700 °C

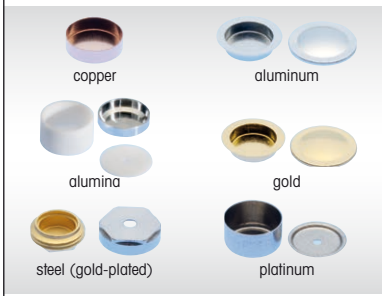
Temperature range and cooling options

You can adapt the system to your requirements depending on the temperature range in which you want to measure. The IntraCooler is a sealed system requiring only electrical power. It is therefore advantageous in locations where liquid nitrogen is undesirable or not available. Liquid nitrogen cooling offers greater flexibility because it allows you to measure over the entire temperature range.

Crucibles for Thermal Analysis
Guarantee Reliable Results

Crucibles serve as containers for samples during thermoanalytical measurements. They guarantee that the sensor is not contaminated by the measurement. The type of crucible used for a measurement can have a large effect on the quality of the results obtained, and in addition, also influences important characteristics of the DSC measuring cell. Considering the relevant factors before the measurement can often help to save time later on when interpreting the curve.

Extensive crucible range



We have the right crucible for every application. The crucibles are made of different materials with volumes ranging from 20 to 160 µL* (900 µL all techniques) and for high pressures. All the different types can be used with the sample robot. Available crucibles can be found here:

▸ **www.mt.com/ta-crucibles**

* with furnace expander

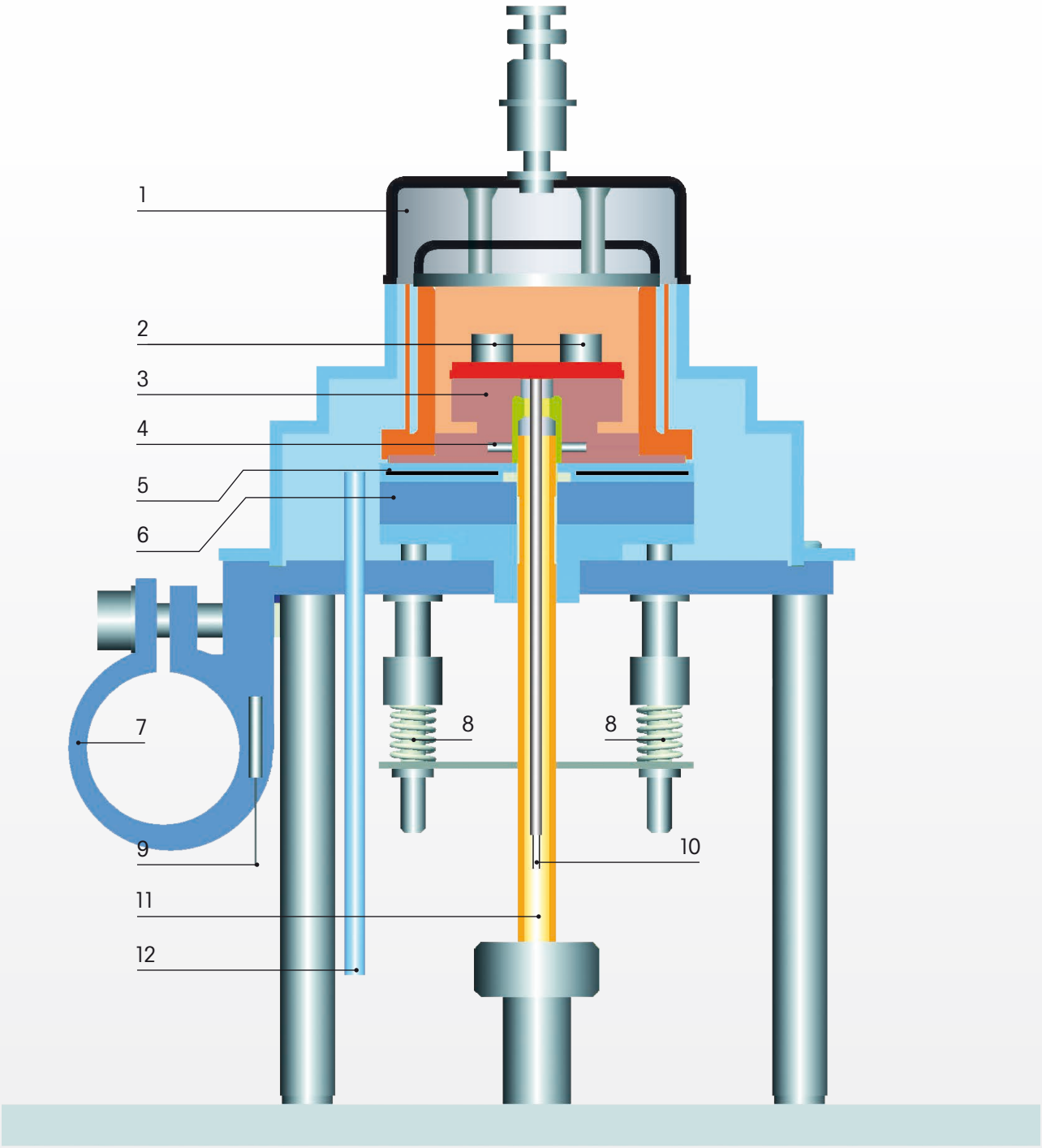
Crucible sealing press and sealing tools

The press allows the pan to be sealed very easily. Under the pressure of the plunger the pan is cold welded, hermetically sealing with the lid. After changing plunger and die you can use the press for other crucibles.

Crucible handling set

The crucible handling set provides a range of tools that are fundamental for sample loading and pan and lid handling:

- A funnel for filling the pan with sample
- Tweezers for handling of sample, pans and lids
- Different type of needles and a piece of rubber for lid preparation
- Crucible holder for crucible handling and safe bringing to the instrument



1. Furnace lid
2. Crucibles on the DSC sensor
3. Silver furnace
4. PT100 of furnace
5. Flat heater between two insulating disks
6. Thermal resistance for cooler
7. Cooling flange
8. Compression spring construction
9. Cooling flange
10. DSC raw signal for amplifier
11. Purge gas inlet
12. Dry gas inlet

Differences in heat flow arise when a sample absorbs or releases heat due to thermal effects such as melting, crystallization, chemical reactions, polymorphic transitions, vaporization and many other processes. Specific heat capacities and changes in heat capacity, for example during a glass transition, can also be determined from the difference in heat flow.

Extremely Wide Application Range
For All Kind of Materials

Differential scanning calorimetry measures the enthalpies associated with transitions and reactions and the temperatures at which these processes occur. The method is used for the identification and characterization of materials.

Differential scanning calorimetry (DSC) is fast and very sensitive. Sample preparation is easy and requires only small amounts of material. The technique is ideal for quality control, material development and material research.

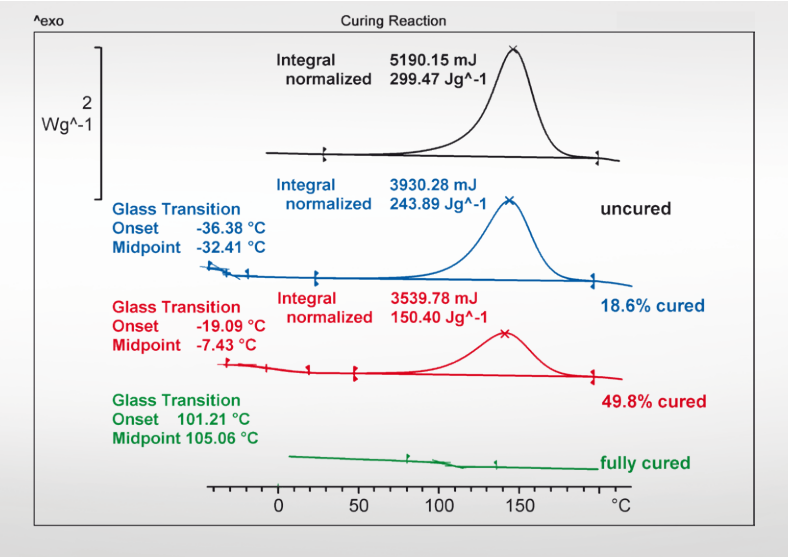
Examples of thermal events and processes that can be determined by DSC

- Melting behavior
- Crystallization and nucleation
- Polymorphism
- Liquid-crystalline transitions
- Phase diagrams and composition
- Glass transitions
- Reactivity
- Reaction kinetics
- Curing
- Stability
- Miscibility
- Effects of plasticizers
- Thermal history
- Heat capacity and heat capacity changes
- Reaction and transition enthalpies
- Purity

The method is used to analyze and study materials such as thermoplastics, thermosets, elastomers, composite materials, metals and alloys, adhesives, foodstuffs, pharmaceuticals and chemicals.

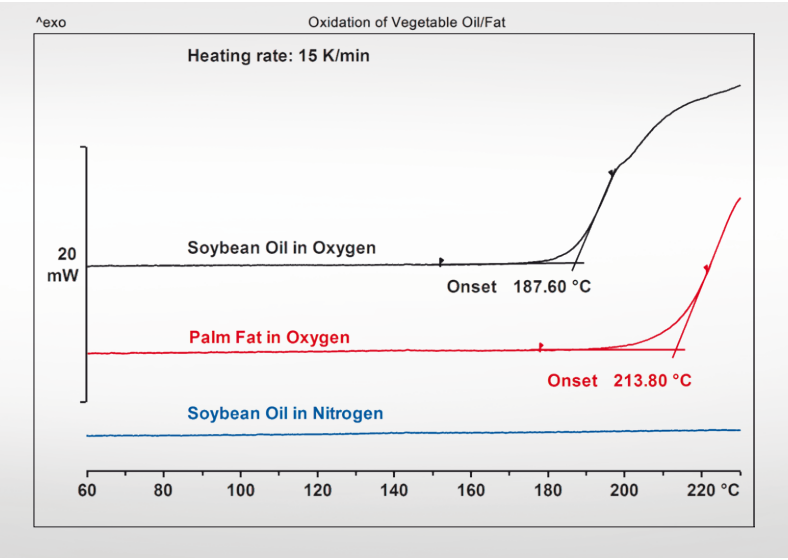
www.mt.com/ta-applications

Epoxy systems



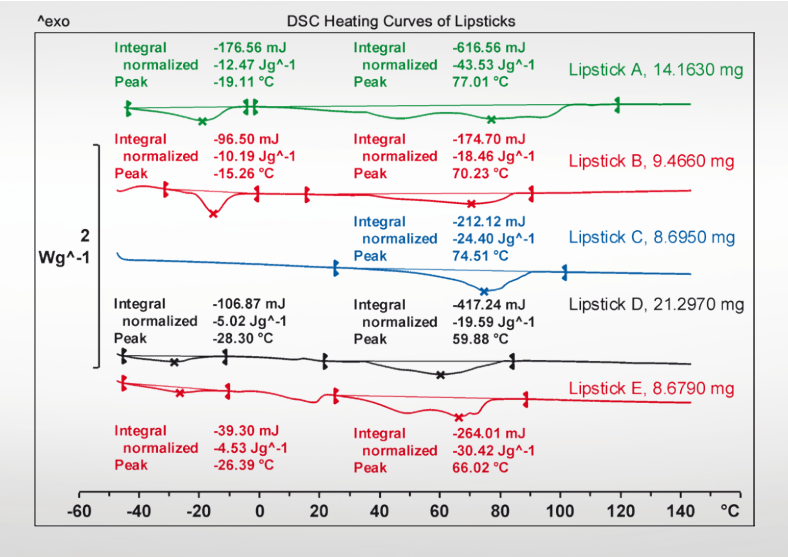
An important application of DSC is to measure the glass transition and the curing reaction in epoxy resin systems. The figure displays the curing curves of samples previously cured to different extents. The results show that as the degree of curing increases the glass transition shifts to higher temperatures and the postcuring reaction enthalpy decreases. If the reaction enthalpy of the uncured material is known (in this example, 299.5 J/g), the degree of conversion can be calculated from the enthalpy of the postcuring reaction.

Oxidation of vegetable oils



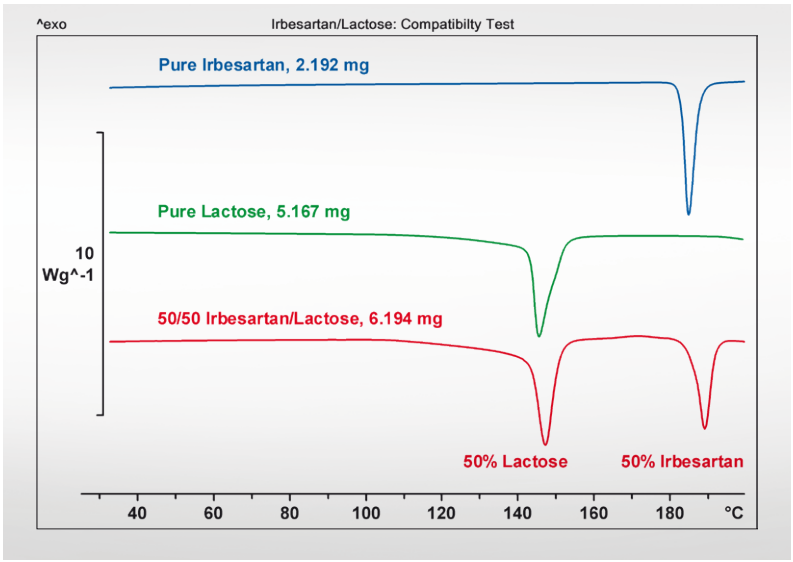
Oxidation causes rancidity in edible oils and fats, giving them an unpleasant odor and taste and making them unsuitable for cooking. By determining the oxidation onset temperature (OOT) the thermal stability can be measured and used oils can be distinguished from fresh oils. The diagram shows the OOT curves of soybean oil and palm fat. In each case, about 2 mg of the oil or fat was weighed into 40-µL standard aluminum crucibles. The soybean oil shows that oxidation begins at about 188 °C under oxygen but shows no visible signs of reaction under nitrogen. Similarly, palm fat begins to oxidize at about 213 °C.

Identification of lipsticks



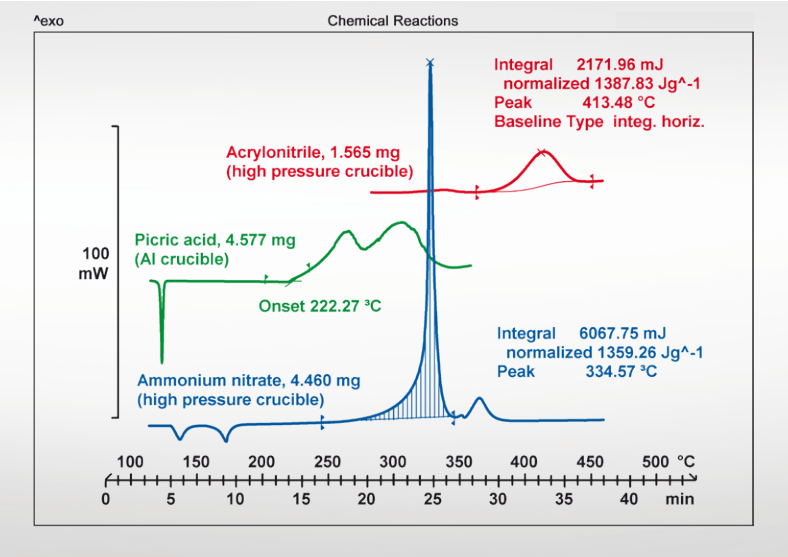
Lipsticks contain waxes, oils, pigments, and emollients commonly known as moisturizers. The diagram shows heating curves of five different lipsticks labeled Lipstick A, B, C, D, and E. Measurements like this are typically performed at heating rates of 5 or 10 K/min. The waxes and oils are initially solid but melt on heating, giving rise to endothermic peaks. DSC analysis can be used to obtain melting profiles and to characterize and distinguish between different lipsticks. The results also provide information about the practical performance of lipsticks. For example, the lower-melting lipstick D should spread well, a higher-melting lipstick like C wear well.

Compatibility in a formulation



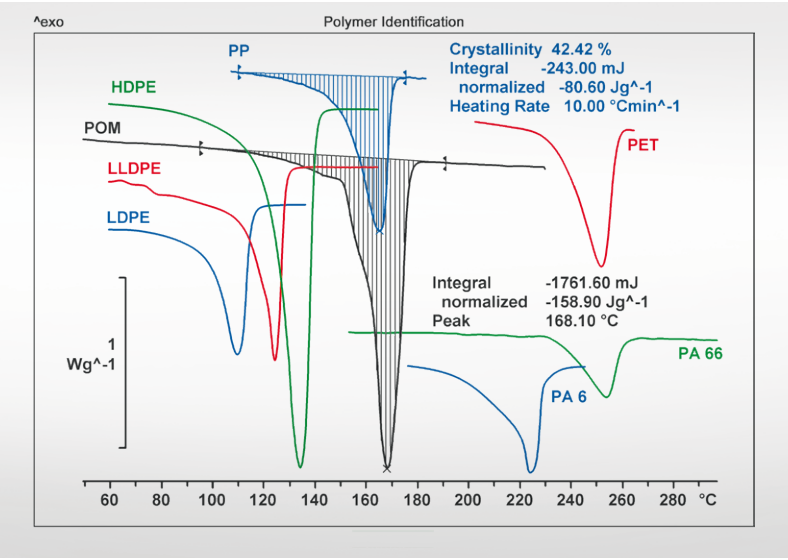
DSC is an important method in preformulation studies to quickly obtain information about interactions between different constituents of a formulation. Pure irbesartan exhibits a melting peak at about 185 °C and pure lactose monohydrate a peak at about 146 °C which is related to the evaporation of water. It can be seen that the melting peak of irbesartan in a 50/50 mixture shows no significant change or shift due to the presence of lactose. This indicates that irbesartan is compatible with lactose monohydrate.

Chemical reactions



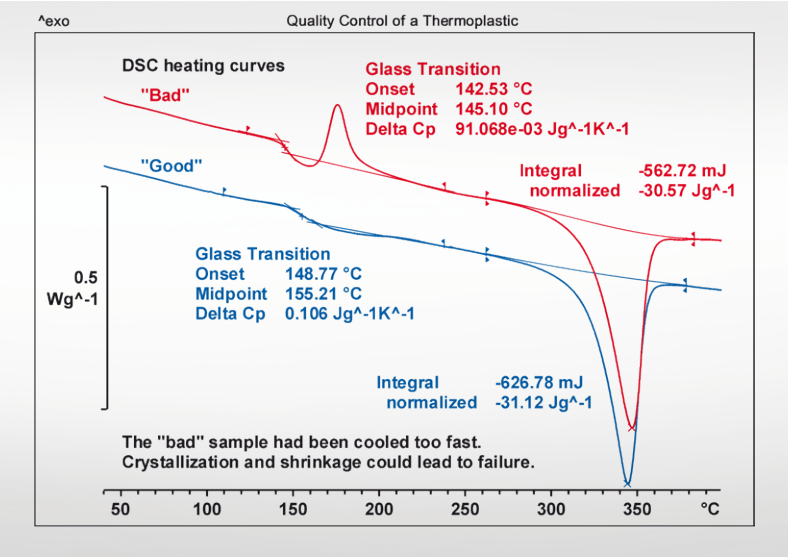
The question of reactivity plays a central role in assessing the stability of chemicals. It is important to know the reaction rate and the energy released in a reaction at a particular temperature. Information about the decomposition reaction that can be obtained from DSC curves is very useful for safety studies, for example with autocatalytic reactions.

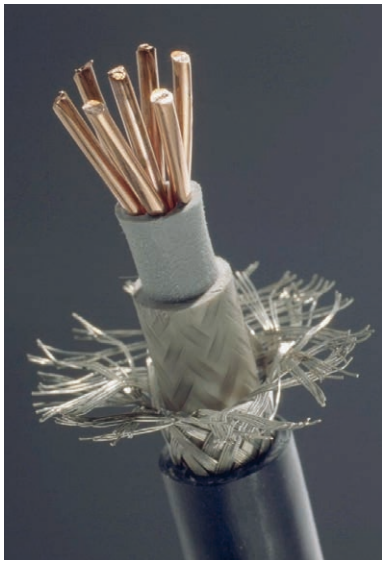
Identification of plastics



Plastics can be identified by measuring their glass transition temperatures and melting temperatures. The figure shows the melting peaks of different polymers. The peaks clearly differ in size and their position on the temperature axis. The example of PP and POM shows that identification depends both on the melting point and on the enthalpy of fusion. If the type of polymer is known, the degree of crystallinity can be determined from the melting peak.

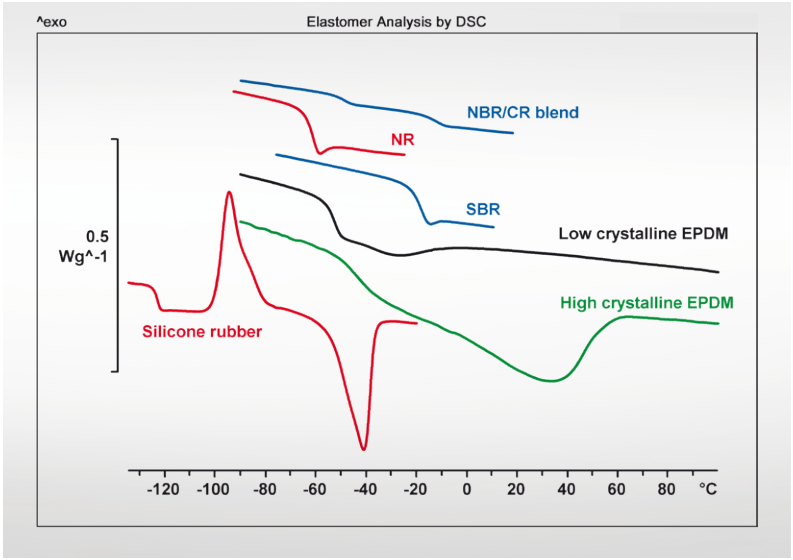
Failure analysis of a thermoplastic

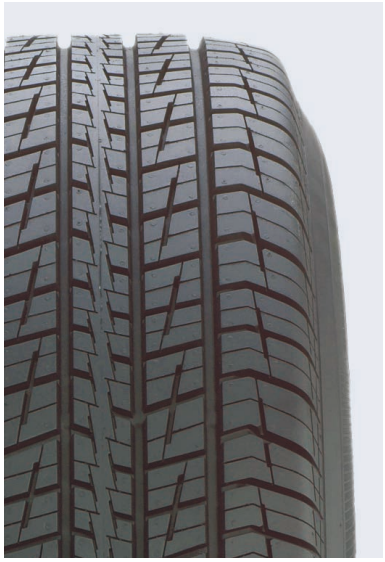




The diagram shows DSC heating curves of two semicrystalline thermoplastic seals. The "Bad" seal failed when the temperature reached about 150 °C. This material exhibited a glass transition at about 145 °C immediately followed by a crystallization process. In contrast, the "Good" material showed just the glass transition at about 155 °C. During crystallization, the material shrinks. This is the reason why the "Bad" seal failed. The different behavior shown by the two seals is due to differences in the processing conditions – the bad seal had been cooled too quickly. As a result of this, the material did not have enough time to crystallize completely.

Elastomer analysis



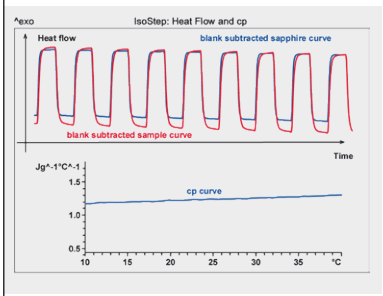


DSC can be used to identify elastomers. The method makes use of the fact that glass transitions and melting and crystallization processes occur below room temperature. These are specific for a particular elastomer. In elastomer analysis, DSC is an important complementary technique to thermogravimetric analysis (TGA).

Simple, Intuitive Operation
Straightforward, Efficient and Secure

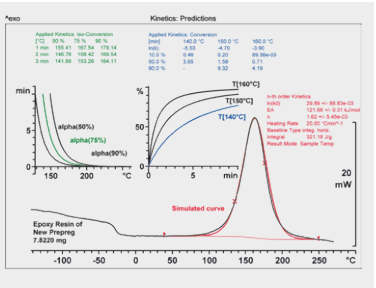
STAR^{e} software has been expanded to include new features that help you prepare your DSC 3 instrument for specific experiments, develop methods for advanced analyses and perform flexible result evaluations. Complex measurement programs are set up within minutes and the vast range of available tools permit curves to be evaluated accurately and efficiently.

IsoStep™



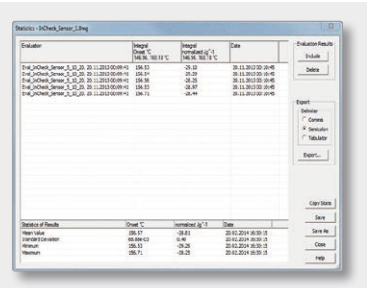
This software option allows simultaneously occurring thermal effects to be separated. The heating program includes isothermal segments, which enable the isothermal drift of the dynamic segments can to be corrected, resulting in better c_p accuracy. Kinetic information, for example of a chemical reaction, can also be obtained from the isothermal steps.

Kinetics (nth order)



The kinetics option is suitable for the analysis and simulation of chemical reactions. It allows you to predict reaction behavior under different conditions as a function of conversion, time or temperature. ASTM International standards E1641 and E698 are commonly used to determine kinetic parameters according to the nth order model.

Quality control



The Quality Control software option provides a fully automated solution for QC workflows. With OneClick™, results are electronically transferred to a QC table, where users can apply statistics or check results against predefined criteria.

A complete thermal analysis system consists of the basic six complementary measuring techniques, each of which brings fast and accurate results. Additional knowledge can be obtained by means of several hyphenated techniques.

www.mt.com/ta-software

World-Class Service and Support
Provide Results You Can Trust

METTLER TOLEDO's portfolio of services is designed to ensure the continuous performance and reliability of your thermal analysis systems. Factory-trained in Switzerland, our worldwide teams bring the professional expertise and know-how needed to provide you with the highest level of after-sales support, as well as the experience necessary to optimize services for your own particular needs.

Large library of overview and how-to videos

Increase your productivity by learning from our video libraries and more than 600 applications.

Videos

▸ **www.mt.com/ta-videos**

Handbooks

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Applications

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Comprehensive training courses

We offer effective classroom training sessions.

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For self-training purposes, you may purchase the tutorial kit consisting of 23 well-chosen application examples and their corresponding test substances.

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Register for an e-training course

▸ **www.mt.com/ta-etraining**

Bi-annual application magazine

Every year, thermal analysis generates a large number of scientific results and discoveries. Interesting examples from different application fields and industries are published in our UserCom magazine.

▸ **www.mt.com/ta-usercoms**

Thermal Analysis eNewsletter
Sign up to receive quarterly news on the latest trends in thermal analysis, including applications, webinars, courses and how-to-videos.

▸ **www.mt.com/ta-knowledge**

METTLER TOLEDO provides several online-teaching and self-learning possibilities. The Tutorial Kit booklet together with the corresponding 17 test substances is excellent for self-study in thermal analysis. The power of thermal analysis is clearly demonstrated with 23 well-chosen examples.

www.mt.com/ta-tutorial

DSC 3 Specifications

Temperature data

Temperature range	air cooling	RT to 500 °C (200 W)	RT to 700 °C (400 W)
	cryostat cooling	–50 to 450 °C	–50 to 700 °C
	IntraCooler	–100 to 450 °C	–100 to 700 °C
	liquid nitrogen cooling	–150 to 500 °C	–150 to 700 °C
Temperature accuracy [1]		± 0.2 K	
Temperature precision [1]		± 0.02 K	
Furnace temperature resolution		± 0.00006 K	
Heating rate [2] RT to 700 °C		0.02 to 300 K/min	
Cooling rate [2]		0.02 to 50 K/min	
Cooling time	air cooling	8 min (500 to 100 °C)	9 min (700 to 100 °C)
	cryostat cooling	5 min (100 to 0 °C)	
	IntraCooler	5 min (100 to 0 °C)	
	liquid nitrogen cooling	15 min (100 to –100 °C)	

Calorimetric data

Sensor type		FRS 5+	HSS 8+
Sensor material		Ceramic	
Number of thermocouples		56	120
Signal time constant		1.8 s	3.1 s
Indium peak (height to width)		17	6.9
TAWN	resolution	0.12	0.20
	sensitivity	11.9	56.0
Measurement range	at 100 °C	± 350 mW	± 160 mW
	at 700 °C	± 200 mW	± 140 mW
Resolution		0.04 µW	0.02 µW
Digital resolution		16.8 million points	

Sampling

Sampling rate	maximum 50 values/second

Special modes

ADSC	standard
IsoStep™	optional
TOPEM™	
Automation	
Photocalorimetry	

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

Specifications and approvals for the IntraCooler option are only valid for systems with Huber coolers.

[1] based on metal standards
[2] depends on instrument configuration

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For more Information

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Quality certificate. Development, production and testing according to ISO 9001.

Environmental management system according to ISO 14001.

"European conformity". The CE conformity mark provides you with the assurance that our products comply with the EU directives.