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.**

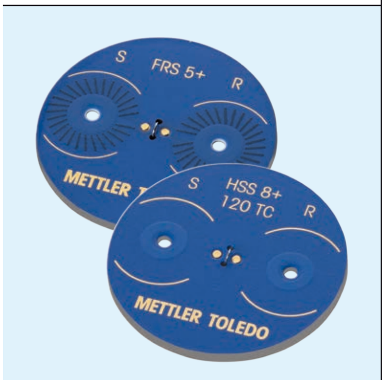
**Features and benefits of the METTLER TOLEDO DSC 3:**

- **Rugged MultiSTAR® 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 One Click™** – 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 a robust and versatile DSC sensor with 56 thermocouples which guarantees simultaneous outstanding resolution and sensitivity.**

# Major Breakthrough in DSC Sensor Technology

## Unsurpassed Sensitivity and Excellent 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

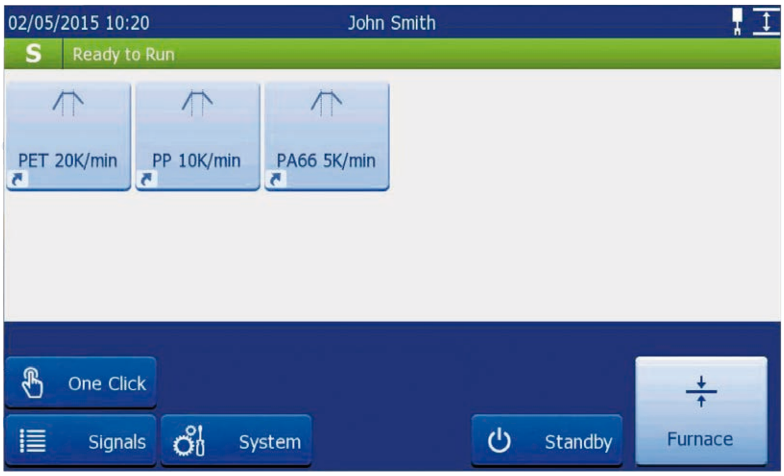
The signal time constant determines how well close-lying or overlapping thermal effects are separated from one another. We set unprecedented and unparalleled performance standards due to our high thermal conductivity ceramic sensor material with its low thermal mass.

### 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.

### FRS 5+ sensor

The Full Range FRS 5+ sensor has 56 thermocouples and provides high sensitivity and unprecedented temperature resolution. Thanks to its ceramic surface it is robust and chemically resistant making it ideal for daily use.



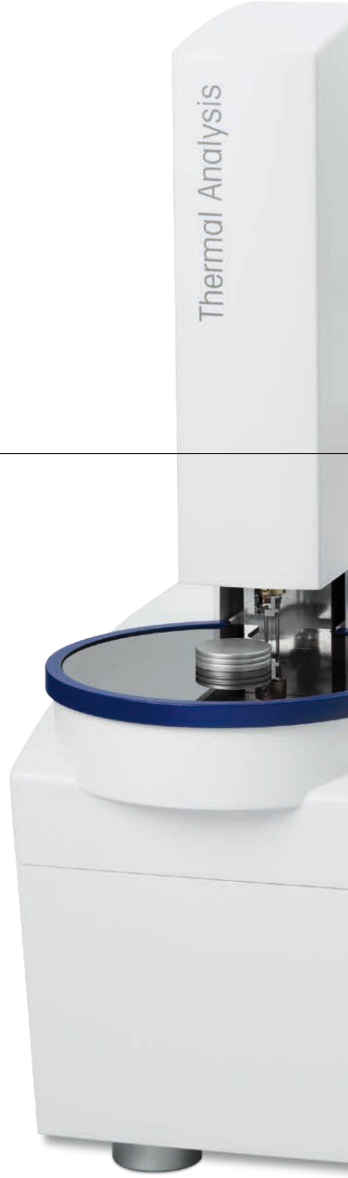

### One Click™ function

The patented One Click™ function allows you to start predefined methods safely and easily from the terminal at the touch of a button.

Swiss Quality

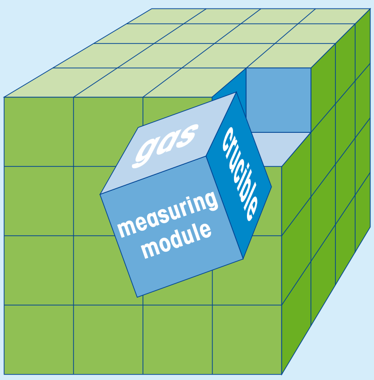
# DSC 3 from METTLER TOLEDO
## the Right Decision

**SmartSens terminal with One Click™ function**
The terminal with the One Click™ function is clearly visible even at a distance and provides information on the status of the measurement. The One Click™ function allows you to easily and efficiently start a predefined method.
If the DSC is not installed next to a PC running the STAR$^e$ 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.





**Furnace chamber**
The sensor is located in a corrosion-free silver furnace.




**FlexCal® adjustment**
The STAR$^e$ software stores a complete adjustment data record in the database for every crucible, gas and module combination. The module always uses the correct adjustment parameters, even if measurements are performed with different crucibles or if the gas is switched during the measurement.


## Ergonomics in Perfection
We Care about You

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

**DSC**


**TGA**

**TMA**

**DMA**

**Complete thermal analysis system**
A complete thermal analysis system comprises four different techniques. Each technique characterizes the sample in a particular way.

The combination of all the results simplifies interpretation. DSC measures the heat flow, TGA the weight curve, TMA the length change, and DMA the modulus.

The powerful STAR$^e$ software allows the user to control all the connected modules and provides unlimited evaluation possibilities.

**Support and repair**
Support and diagnosis in case of technical issues. Carrying out repairs at a customer's site or at one of our service centers.

**Quality assurance and certification**
Qualification, documentation, calibration with certificate.

**Performance services and preventive maintenance**
Professional installation (IQ, OQ) and ensuring optimum performance during the life-time of the instrument (PQ and preventive maintenance).

**Training and applications support**
Professional applications support, basic and customized training courses, comprehensive applications literature.

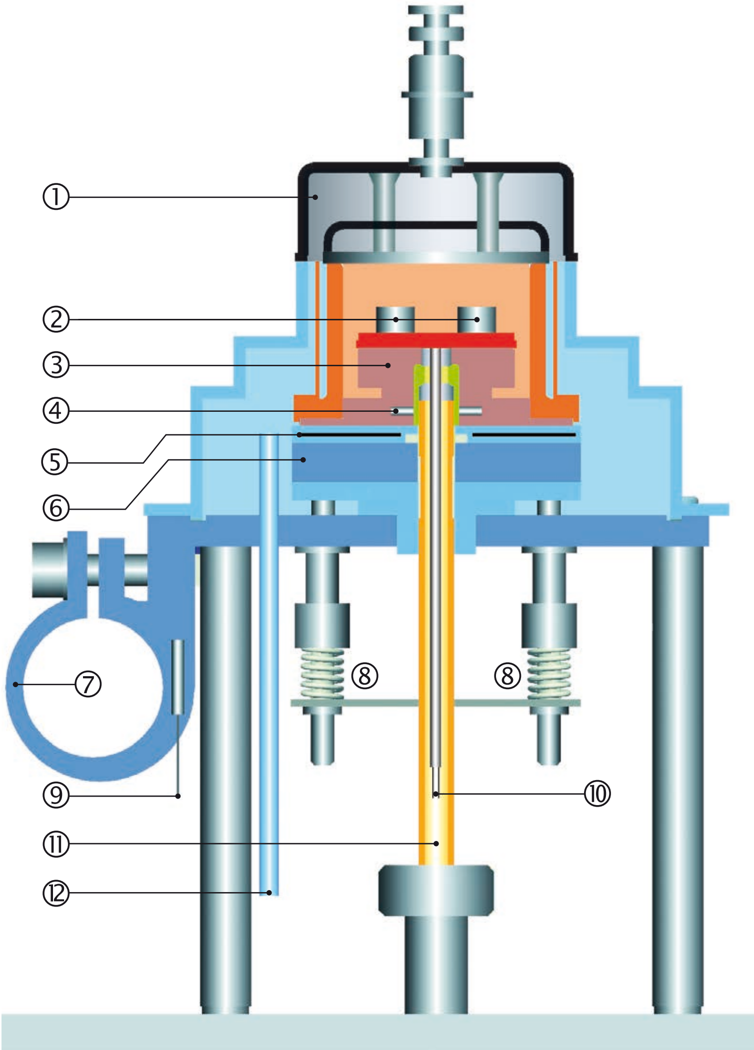
# **Unsurpassed Performance**
## over the Whole Temperature Range

### Measurement principles

Differential scanning calorimetry (DSC) measures the difference between the heat flows from the sample and reference sides of a sensor as a function of temperature or time.

### Physics of DSC

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.

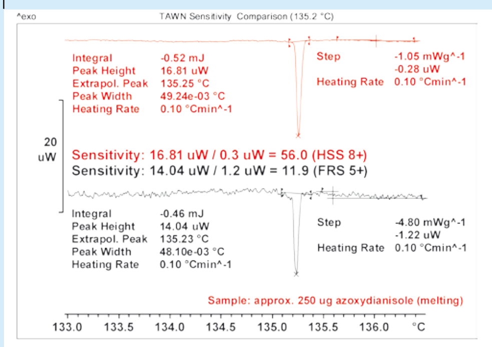


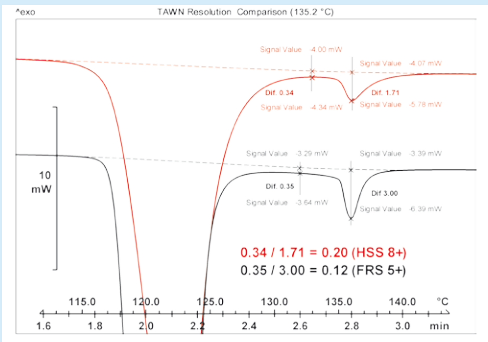

### TAWN test

The benchmark for DSC sensors is the widely used TAWN test. The test confirms the excellent sensitivity and high temperature resolution of the HSS 8+ and FRS 5+ sensors.

**Key**

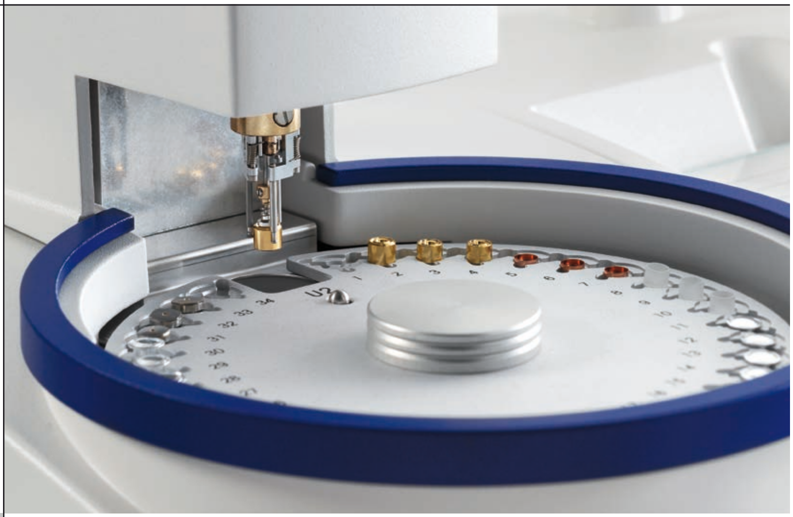
1. Furnace lid
2. Crucibles on the DSC sensor
3. Silver furnace
4. PT100 of furnace
5. Flat heater between two insulating disks
6. Thermal resistance for cooler
7. Cooling flange
8. Compression spring construction
9. Cooling flange PT100
10. DSC raw signal for amplifier
11. Purge gas inlet
12. Dry gas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



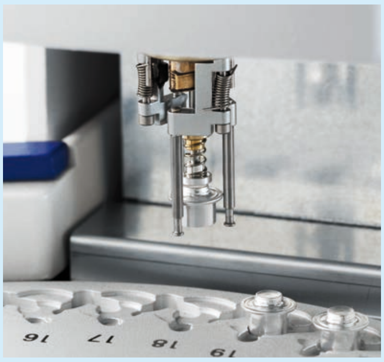
## **Reliable Automation**
Saves Time

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



**Automatic and efficient**
All DSC 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.

**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



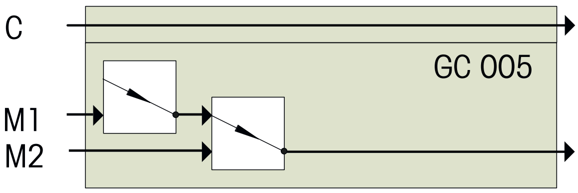
**No sample reaction before measurement**
The sample robot can remove the protective crucible lid from the crucible or can pierce the lid of hermetically sealed aluminum crucibles immediately before measurement. This unique feature prevents the sample from taking up or losing moisture between weighing-in and measurement. It also protects oxygen-sensitive samples from oxidation.

# Modularity and Upgradeability
## Unlimited Possibilities

**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.

| | |
|---|---|
| Air cooling | RT to 500 °C / 700 °C |
| Cryostat cooling | –50 to 450 °C / 700 °C |
| IntraCoolers (several) | –35 to 450 °C / 700 °C<br>–85 to 450 °C / 700 °C<br>–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.




**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.

| 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) | | | | recommended | | | optional | | | | |
| Gas flow-switch (GC 005) | | | | optional | | | optional | | | | |
| Cryostat / Intracooler | | | | | | optional (recommended) | | | | | |
| Liquid nitrogen cooling | | | | | essential | | | | | | |

• = selectable

## **Innovative Accessories**
Increase Measurement Power

**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.

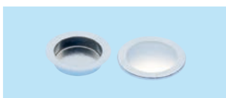

**DSC photocalorimetry**
The photocalorimetry accessory for the DSC allows you to characterize UV curing systems. You can study photo-induced curing reactions and measure the effects of exposure time, UV light intensity and temperature on material properties.


Crucible sealing press

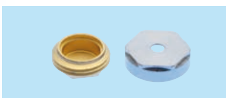
**Enormous range of crucibles**
We have the right crucible for every application. The crucibles are made of different materials with volumes ranging from 20 to 900 µL and for high pressures. All the different types can be used with the sample robot.

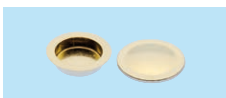
Crucible materials available include:


copper


aluminum


alumina


steel (gold-plated)


gold


platinum

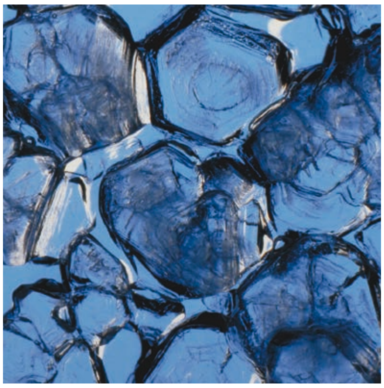
# Extremely Wide Application Range

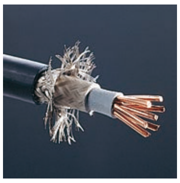
**Differential Scanning Calorimetry measures the enthalpies associated with transitions and reactions and the temperatures at which these processes occur. The method is used for the identification and characterization of materials.**

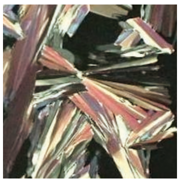
Differential scanning calorimetry (DSC) is fast and very sensitive. Sample preparation is easy and requires only small amounts of material. The technique is ideal for quality control, material development and material research.

DSC is the method of choice to determine thermal quantities, study thermal processes, and characterize or just simply compare materials. It yields valuable information relating to processing and application conditions, quality defects, identification, stability, reactivity, chemical safety and the purity of materials.

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

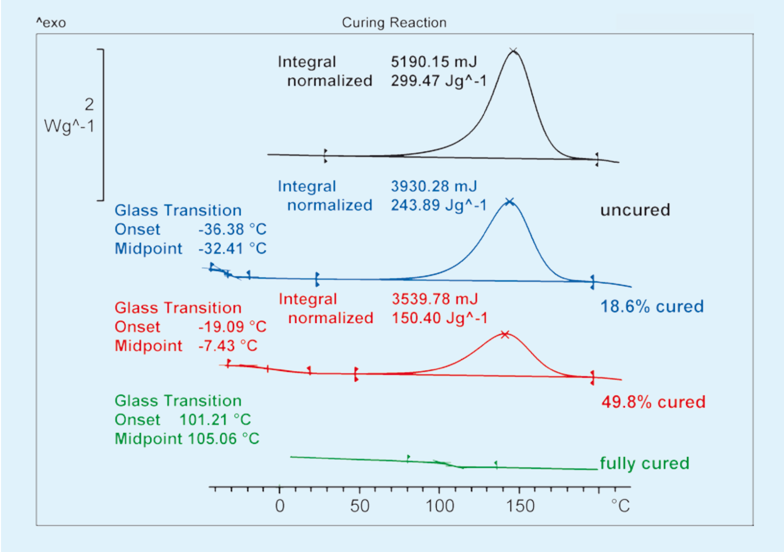






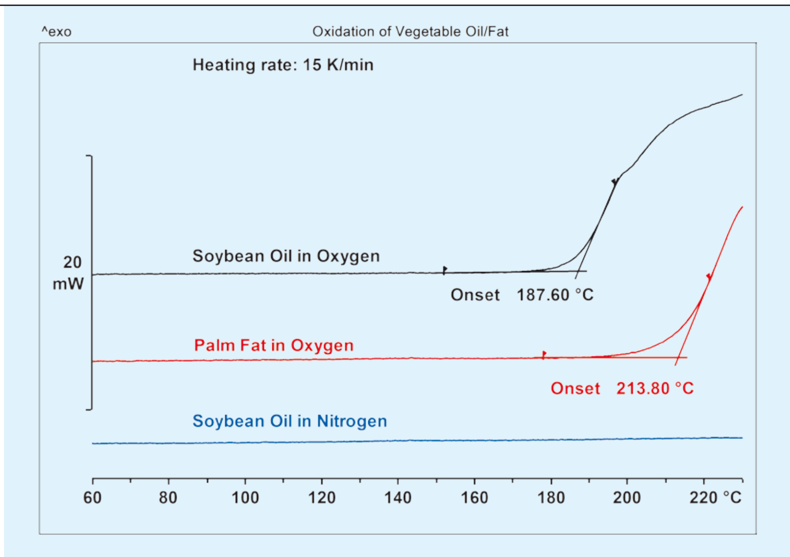
**Examples of thermal events and processes that can be determined by DSC**

- 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



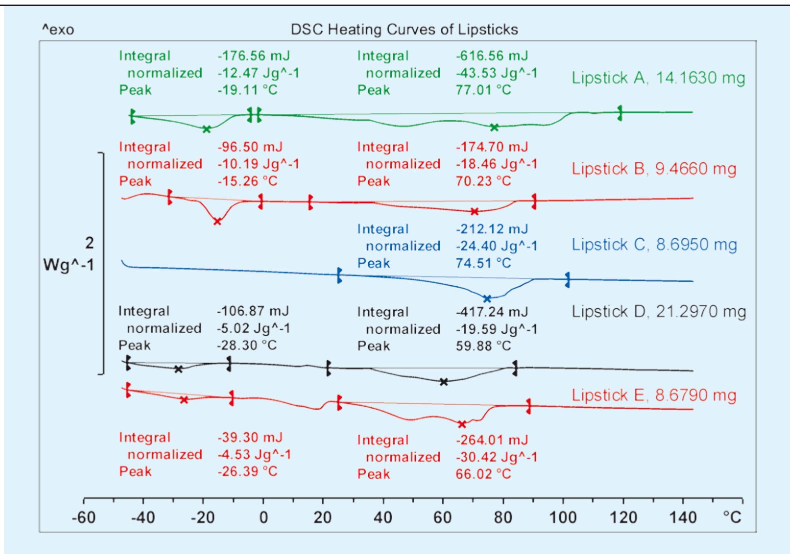

## Epoxy systems

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 cure 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.



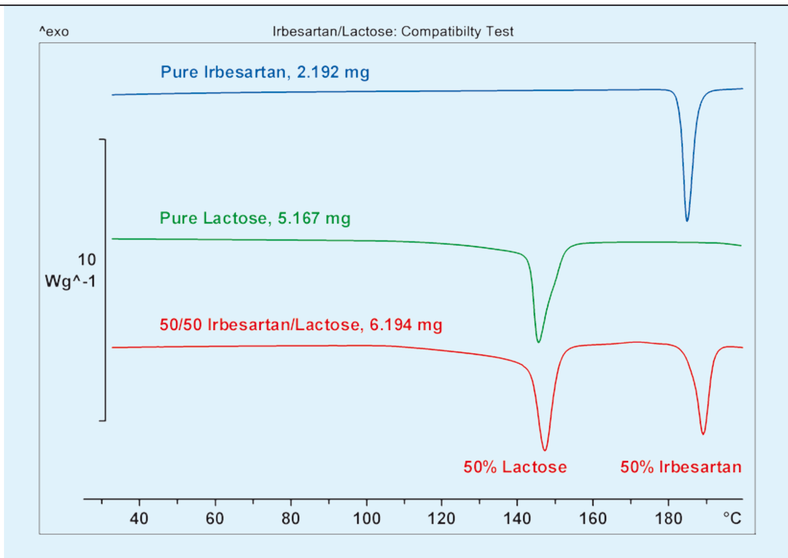

## Oxidation of vegetable oils

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.



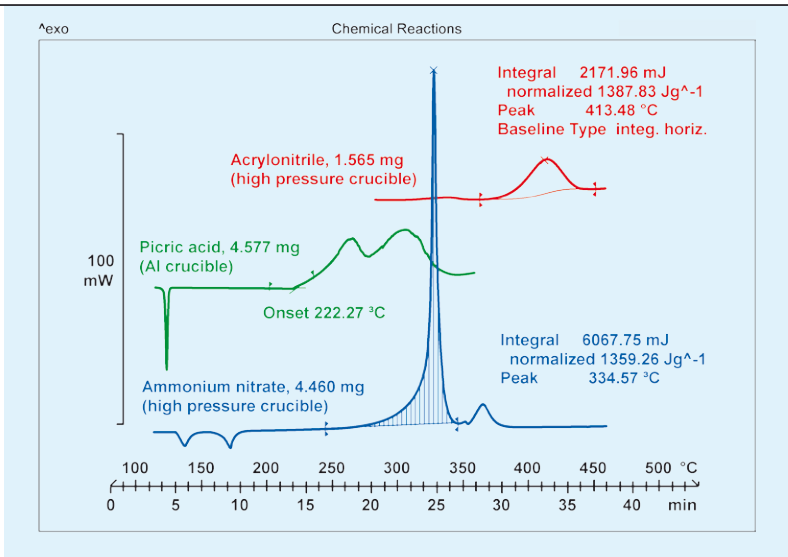

## Identification of lipsticks

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.



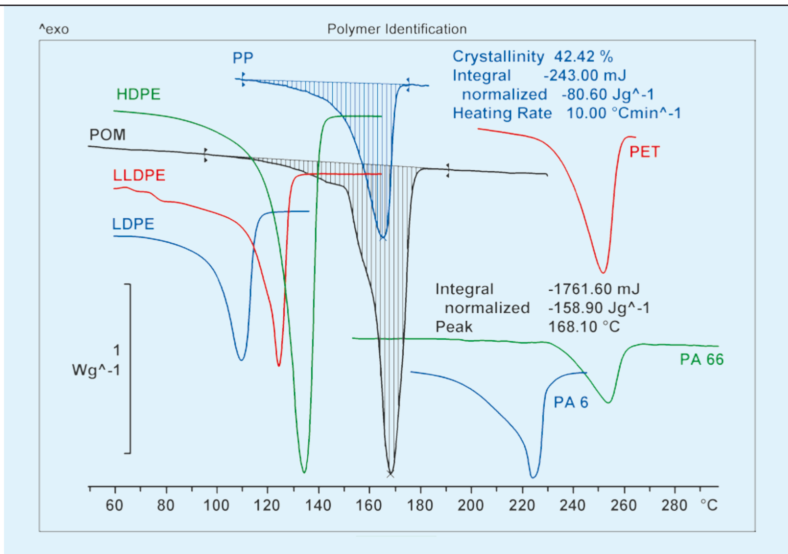

## Compatibility in a formulation

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.



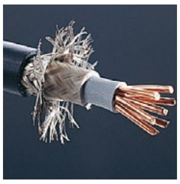

## Chemical reactions

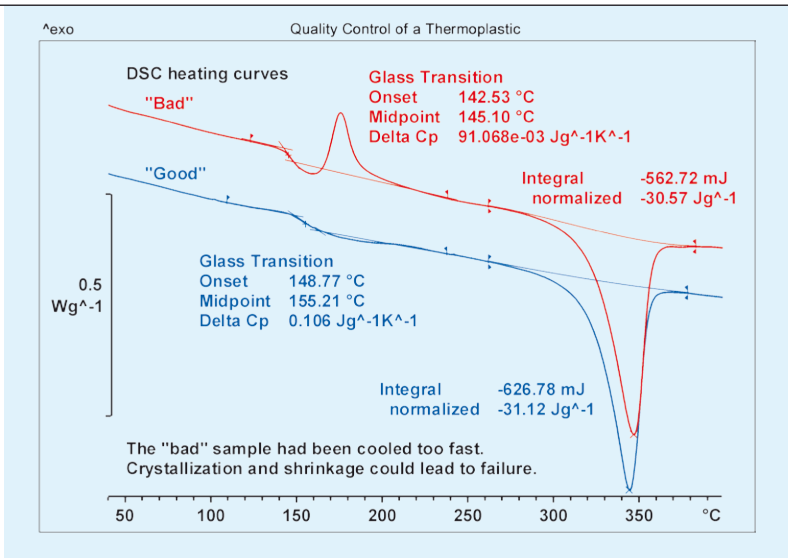
The question of reactivity plays a central role in assessing the stability of chemicals. It is important to know the reaction rate and the energy released in a reaction at a particular temperature. Information about the decomposition reaction that can be obtained from DSC curves is very useful for safety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




## Identification of plastics

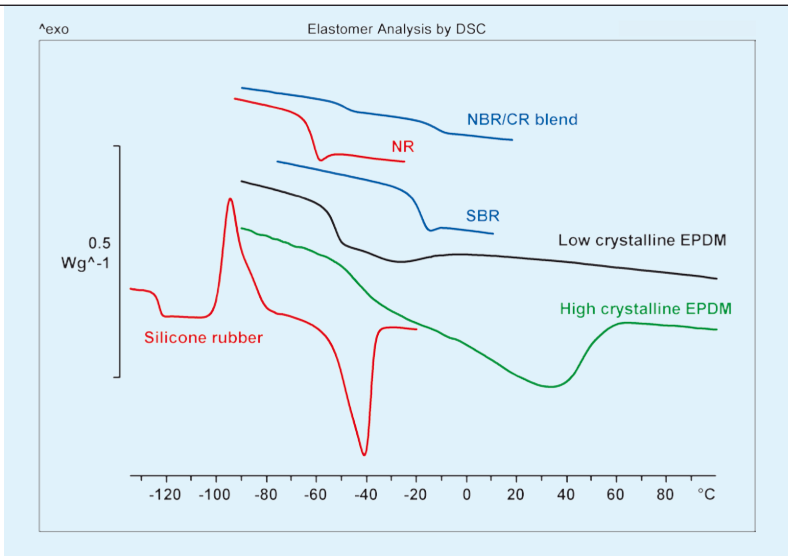
Plastics can be identified by measuring their glass transition temperatures and melting temperatures. The figure shows the melting peaks of different polymers. The peaks clearly differ in size and their position on the temperature axis. The example of PP and POM shows that identification depends both 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.





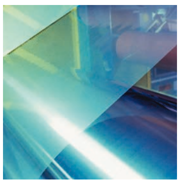

## Failure analysis of a thermoplastic

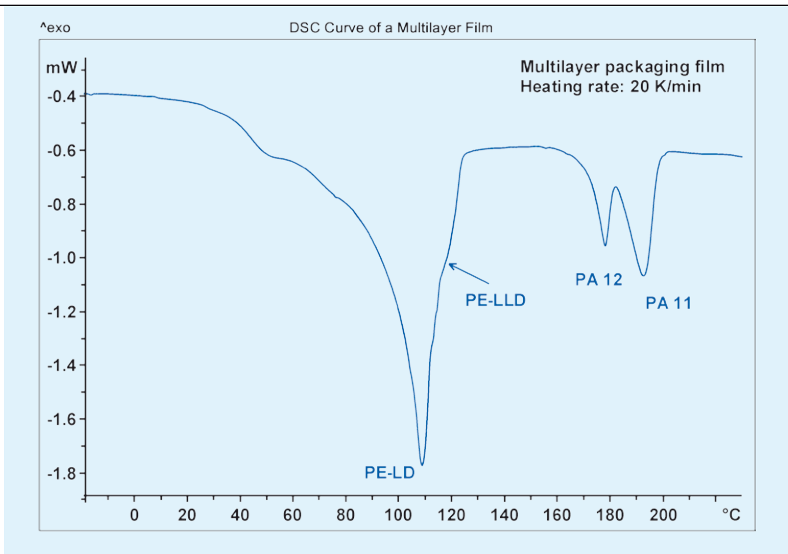
The diagram shows DSC heating curves of two semicrystalline thermoplastic seals. The "Bad" seal failed when the temperature reached about 150 °C. This material exhibited a glass transition at about 145 °C immediately followed by a crystallization process. In contrast, the "Good" material showed just 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).






## Identification of film layers

Flexible food and pharma packaging films are often made of several layers of thin thermoplastic polymer films. This ensures good mechanical and barrier properties. In this example, four different polymers were identified by comparing peak temperatures with reference values. The broad peak with peak temperature at about 108 °C is due to the melting of low-density polyethylene (PE-LD). The shoulder at about 120 °C can be assigned to the melting of linear low-density polyethylene (PE-LLD). The peaks at 177 and 191 °C result from the melting of polyamide 12 (PA 12) and 11 (PA 11), respectively. The small step at 40 °C is due to the glass transition of the polyamide.

# 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 |
| **TOP**EM® | |
| 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

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

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Subject to technical changes

Marketing MatChar / MarCom Analytical

**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.