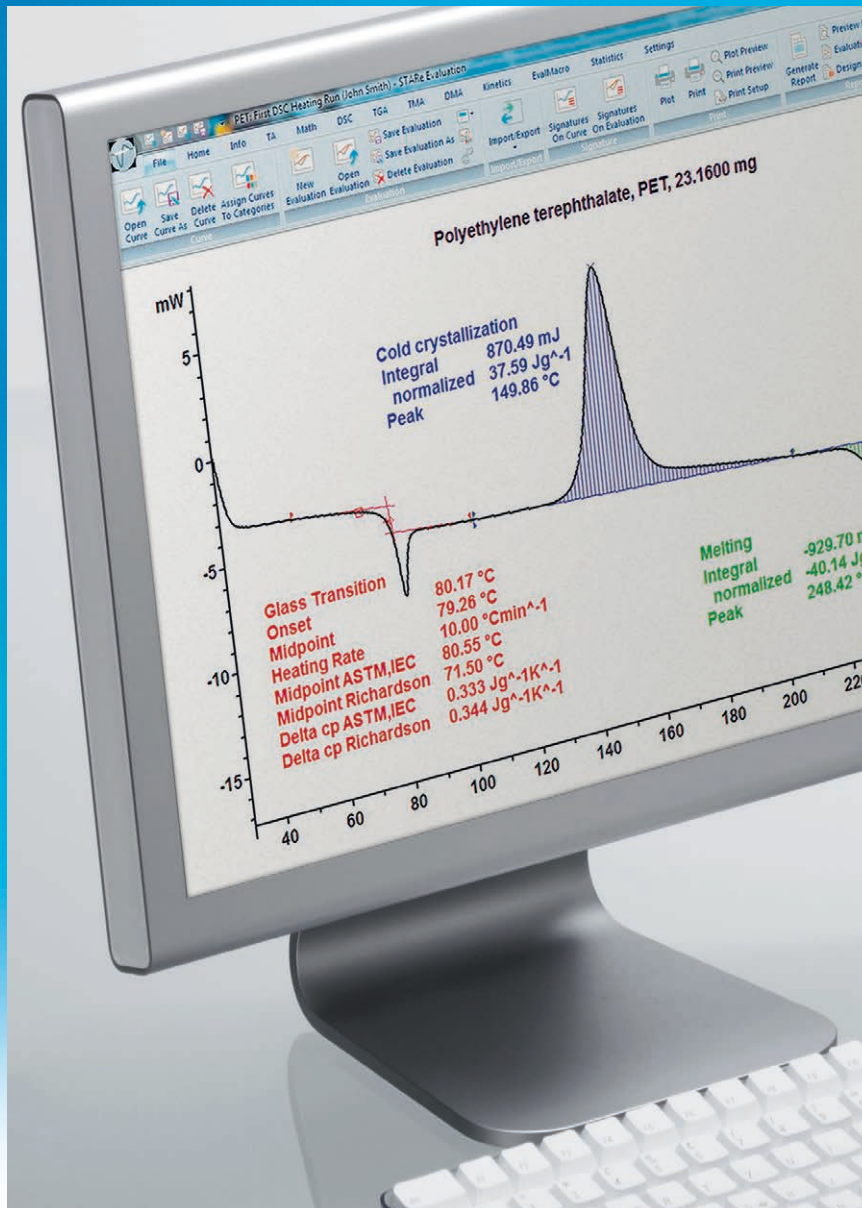


Thermal Analysis Excellence



STAR[®] Excellence Software

Innovative Technology

Versatile Modularity

Swiss Quality

STAR[®] Software

The Standard in Thermal Analysis

METTLER TOLEDO

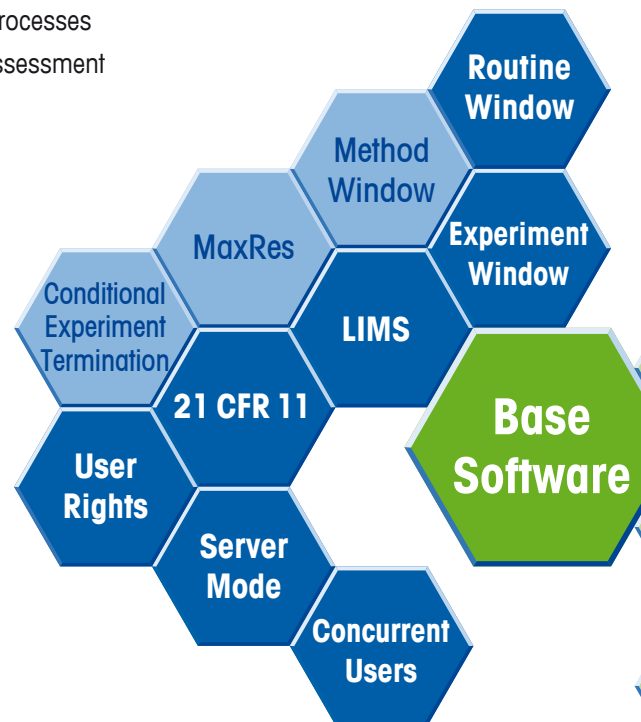
Maximum Flexibility

High Quality Results with Much Less Effort

Thermal analysis is a well-established analytical method that is widely used in many different fields. It provides laboratories with valuable results and new information in quality assurance and control, process and product development, and research. Many problems can be solved by using a combination of different thermal analysis techniques.

Features and benefits of the STAR[®] Excellence Software:

- **Unlimited evaluation possibilities** – enormous flexibility
- **Reliable automation** – high sample throughput with result assessment dramatically improves efficiency
- **Integrated database** – guarantees the highest level of data security
- **Solid compliance** – 21 CFR Part 11 user level management and electronic signatures
- **Modular concept** – tailor-made solutions for current and future needs
- **Easy and intuitive OneClick™ operation** – saves time in training and in daily use
- **Time-saving FlexCal® calibration** – for more accurate measurement results
- **State-of-the-art LIMS integration** – guarantees seamless processes from external tasks to measurement evaluation and result assessment



STAR[®] is the most complete and comprehensive thermal analysis software on the market and provides unrivalled flexibility and unlimited evaluation possibilities.



Safe results

Your data is archived in a database, just like a pearl in its shell. Data is securely protected against loss or modification and can be accessed very quickly.

Simple operation

Thanks to its amazing functionality and Ribbon style toolbar, the STAR[®] software is extremely intuitive and easy to use. Many of its features such as OneClick™, multiple curve handling, and specific options like Quality Control or Reference Library simplify routine work.

Benchmark for flexible evaluation

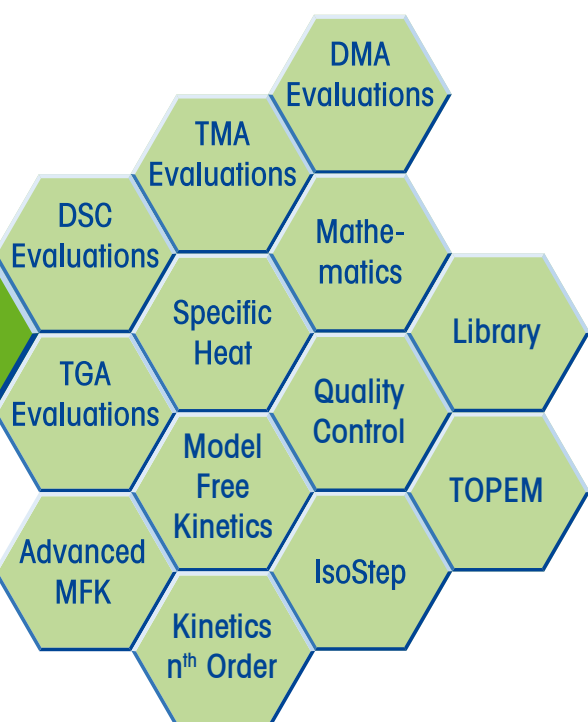
A complete software package and expert evaluation possibilities are the basis for the correct interpretation of measurement results. The STAR[®] evaluation software combines application-specific evaluation tools optimized for thermal analysis users with the flexibility of a superior layout program whose functionality sets no limits to individual creativity.

Automation for enhanced productivity

In routine operation, you can automate everything from the measurement to the evaluation and final result assessment.

Modular concept

The STAR[®] software consists of the Base software and a large number of application-specific software options. This concept makes it very flexible. It allows you to satisfy your current needs and meet any future requirements.



Simple, Intuitive Operation

Straightforward, Efficient and Secure

Five programs – one database

The STAR[®] software utilizes five main programs (windows) linked to one another via the database.



The Installation Window

allows you to set up instruments, create users and enter data concerning reference materials or other information relevant to the database.



The Module Control Window

represents the measuring modules or balances that are connected. The window allows you to create simple methods and experiments for routine operation.



The Method Window

is only required if you want to graphically create complex methods (e.g. when using **TOPEM[®]**).



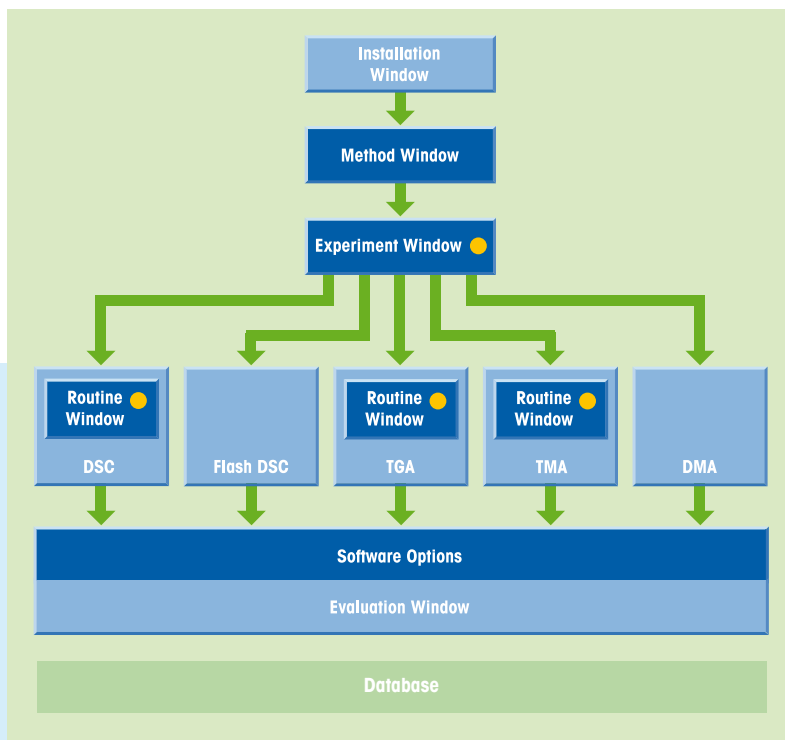
In the Experiment Window

you choose the method, enter the data specific for the experiment and the measurement begins.



The Evaluation Window

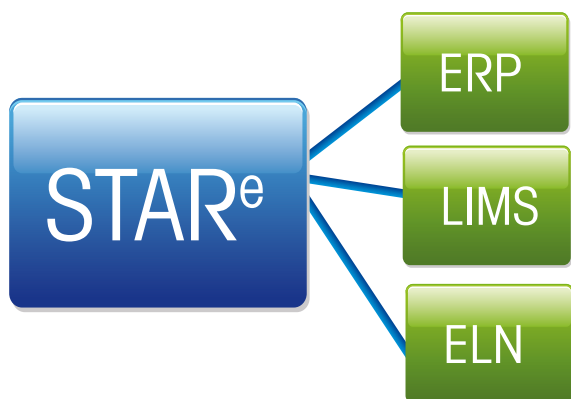
is included in the Base software and provides you with comprehensive and almost unlimited evaluation possibilities.



● You need either the Experiment Window or the Routine Window to perform measurements.

Seamless Processes

from Sample Entry to the Result



LIMS integration simplifies the laboratory workflow. In addition, control functions supervise the status of the system and facilitate serviceability and maintenance.

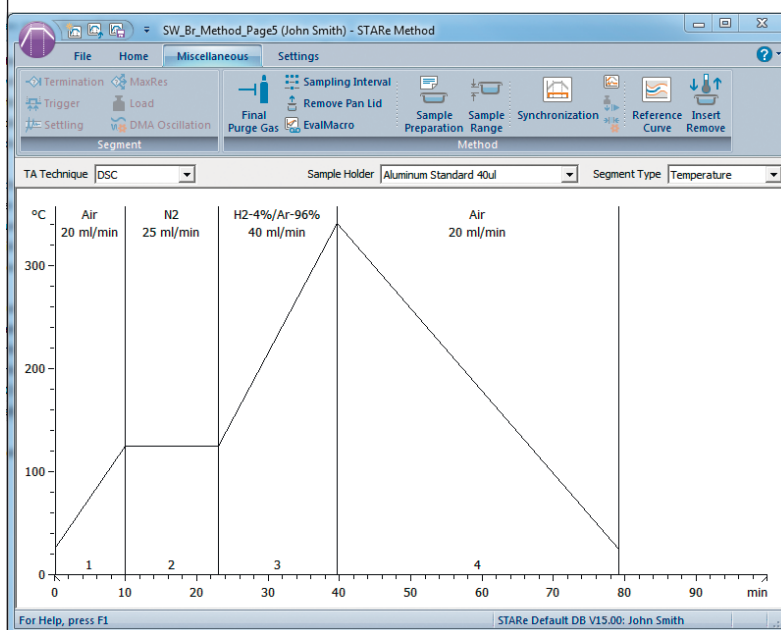
The STAR^e system is designed to maximize productivity. OneClick™ allows users to quickly start predefined methods.

The Routine Window enables users to define their methods in the Module Control Window.

Graphical method development

The Method Window is used to program practically any type of temperature profile. The temperature profile is developed and modified graphically.

A large number of complex operations such as loops, conditional termination, lid handling or automatic baseline correction result in well-designed experiments.



Reference Application Library

The reference library functionality allows you to use different criteria to search for similar curves. This helps you to identify the measured sample. You can either upload a commercially available thermal analysis database or set-up your own reference library.

Keep a clear overview

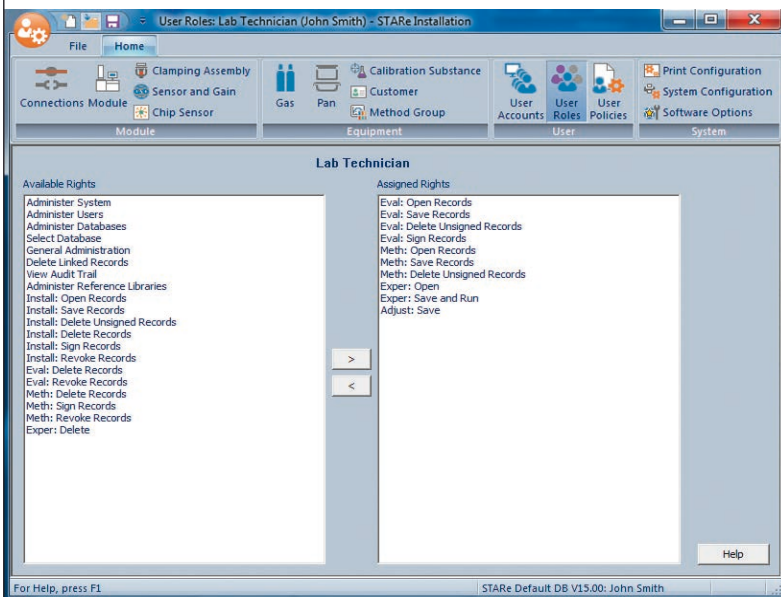
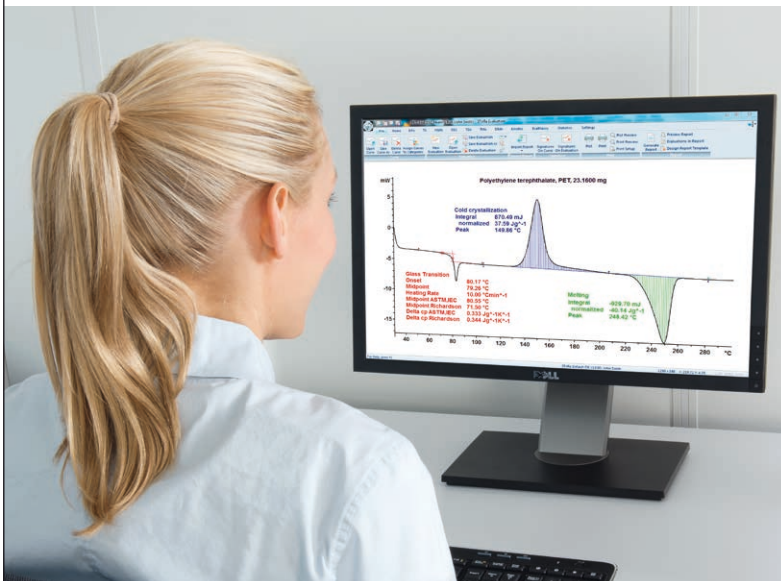
The integrated relational database helps you easily maintain a clear overview even with very large amounts of data. Data is stored within the secure database by sample name, date and time. The Base software allows other data filter parameters to be assigned, simplifying data searches.

The User Rights software option enables you to grant each user specific rights (e.g. as a user, development chemist and lab manager).

GMP and 21 CFR Part 11 compliant

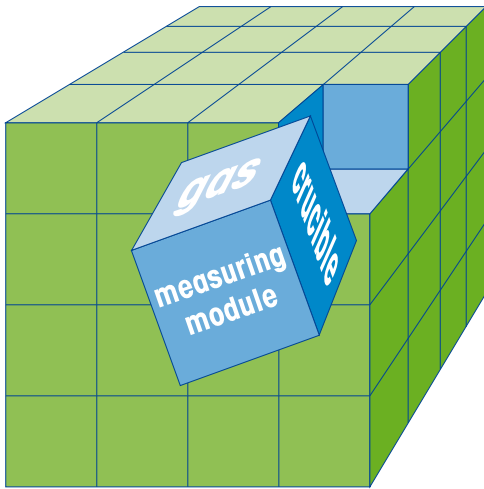
In general, the raw data cannot be changed. The CFR operating mode incorporates additional security features stipulated by the FDA in the 21 CFR Part 11 regulations (electronic signature and audit trail). This means that signed electronic records are stored in the database.

Database Management Unbeatable Data Security



Network capability

The STAR[®] software can be operated stand-alone or in a client/server architecture within a network. In the client/server mode, users can simultaneously perform measurements and evaluations on modules that can be located at different sites (multi-user / multi-tasking mode).



Optimum measurement performance thanks to comprehensive calibration possibilities

Special attention has been paid to calibration and adjustment. Calibration and adjustment should be as easy as possible but at the same time allow complete flexibility.

The full performance capability of the instrument can only be utilized when calibration and adjustment have been properly completed.

FlexCal® for Accurate Results

Minimizes Calibration and Adjustment Time

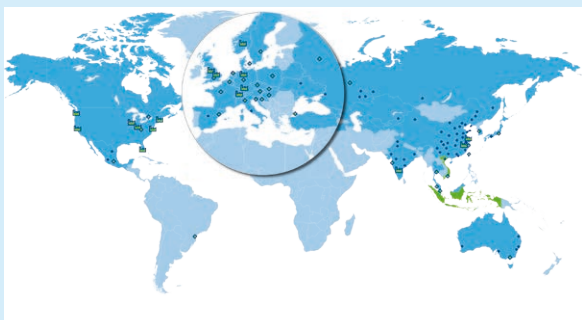
FlexCal® adjustment

The STAR® 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.

Parameters that can be adjusted

- Temperature
- Measuring cell characteristics (tau lag): After adjustment has been successfully completed, isothermal temperatures and onset temperatures are identical, even at different heating rates.
- Sensors: with DSC the heat flow, with TGA the weight, with TMA the length, and with DMA the force, displacement and phase difference.



World class service and support: constant quality and dependability

Dedicated local sales and service engineers are ready to assist you.

Trained in Switzerland, they bring the experience and expertise necessary to advise you on the services we offer and to optimize them for your particular needs:

- Comprehensive equipment qualification and documentation (IQ, OQ, PQ)
- Preventive maintenance and repair
- Standard and Expert calibration and adjustment services
- Training and application advice

Unparalleled Evaluation Possibilities

The Right Solution for Every Measurement

Comprehensive evaluation possibilities already included in the base software

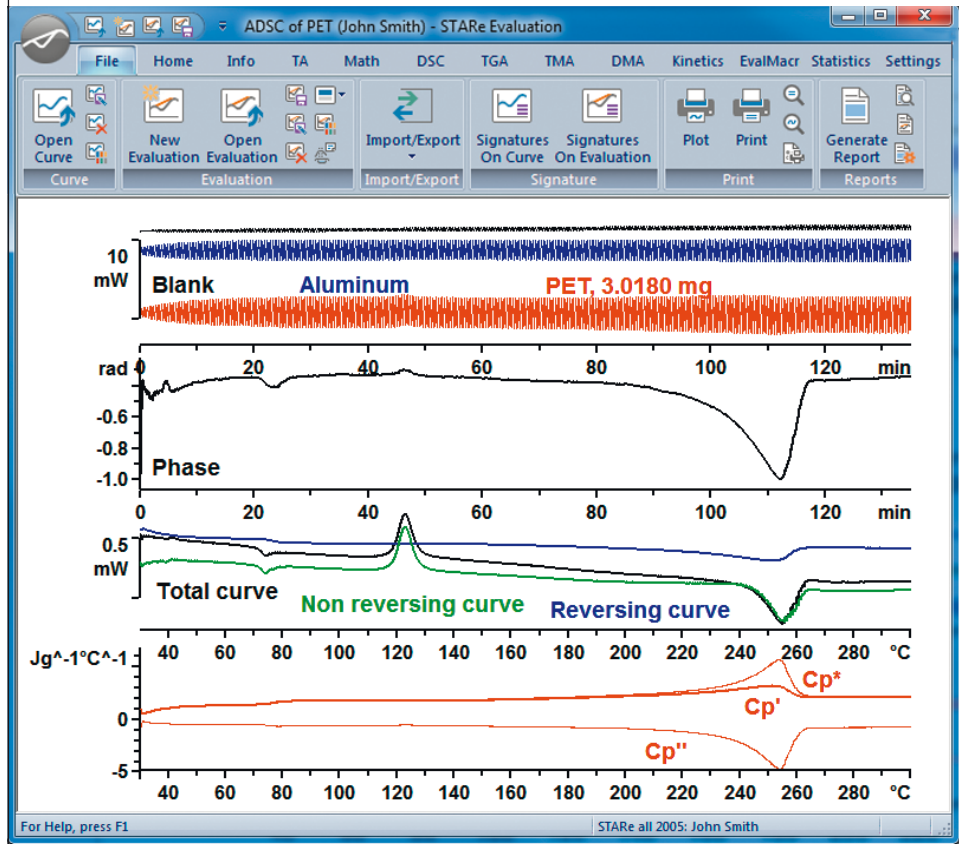
The Base software includes a large number of routine evaluations that can be applied to curves from all the different measurement techniques.

Mathematical evaluation features included in the Base software

- First derivative
- Cut to frame – cutting segments
- Take apart
- Envelope curves

Automatic evaluation

If you frequently have to perform the same measurements, you can fully automate the process. Simply create an Evaluation Macro based on the first measurement. A unique feature is to let the system set the evaluation limits.



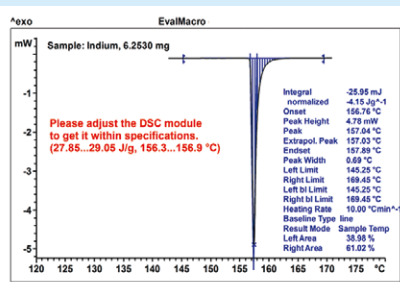
Comprehensive evaluation functionality included in the Base software

- ADSC – FFT, steady state ADSC and ADSC to separate overlapping effects (C_p and kinetic parts)
- Onset and endset, with and without threshold values
- Integration and Peak
- Step, with horizontal or tangential baselines
- Table: many different possibilities to present curves in tabular form
- Min Max: determination of the minimum and the maximum within a region
- Normalization to sample size: conversion to W/g or % presentation
- Curve displayed against time, reference or sample temperature
- DSC purity
- Automatic evaluations and validations

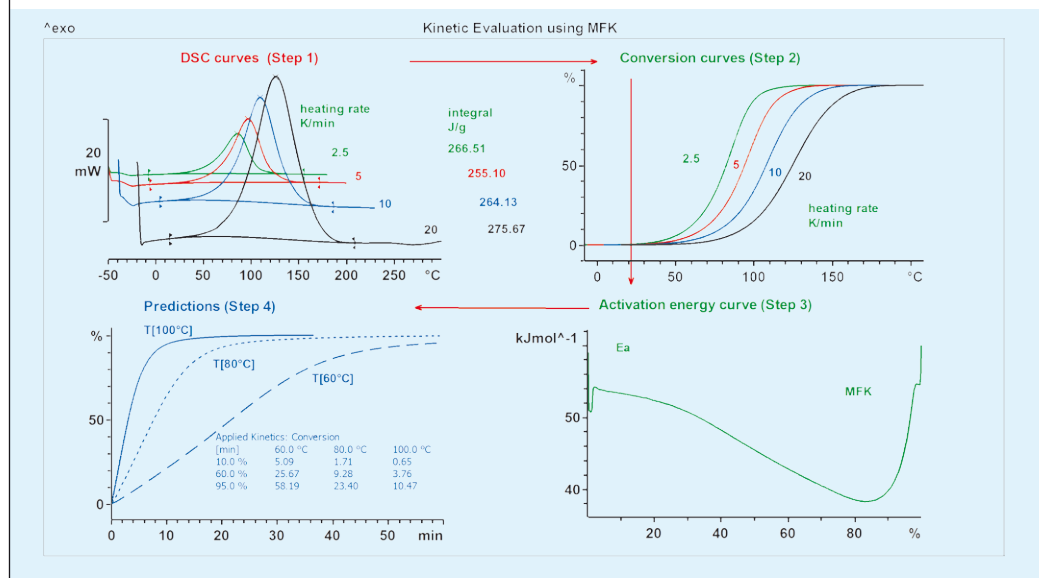
Automatic result assessment (EvalMacro mode)

You can define acceptability limits for each result line. The system uses this range to assess the result after the evaluation in the same way as you would do. If a result lies inside or outside the expected range, a user-defined pass/fail message appears.

In combination with the sample robot, this offers an enormous degree of flexibility. After sample preparation, you can return to other work until all 34 diagrams have been fully evaluated and printed.



Modular System for Cost-Effective, Tailor-Made Solutions



Evaluation options for tailor-made solutions

Many special application-specific software evaluation options are available in addition to the evaluation possibilities provided by the Base software:

DSC Evaluations	Glass transition, content, conversion and enthalpy
Specific Heat	Specific heat (c_p) and specific heat with sapphire (DIN method)
IsoStep®	Separation into heat capacity and conversion components
TOPEM® (Multi-frequency TMDSC)	Determination of the frequency-dependent heat capacity and separation of overlapping effects
TGA Evaluations	Content and conversion
MaxRes	Event-controlled optimization of the heating rate, based on patents of Prof. Dr. F. Paulik
TMA Evaluations	Glass transition, expansion and conversion as well as Young's modulus determination
DMA Evaluations	The time-temperature superposition principle allows the simulation of material properties outside the measurement range (mHz and GHz range)
Mathematics	Integral and integration, multiply/divide curves or add/subtract curves, subtract line or subtract poly-line, polynomial fit
Kinetics nth order	nth order, ASTM E698, ASTM E1641, isothermal kinetics, simulation, conversion plot and isoconversion plot
Model Free Kinetics	Activation energy curve, simulation, conversion plot and isoconversion plot, based on dynamic curves
Advanced Model Free Kinetics	Activation energy curve, simulation, conversion plot and isoconversion plot, based on any curves
Quality Control	Reference curve and trend tracking with statistical evaluation
Reference Library	Reference Library with possibility to expand and rearrange data

Quality Control

The Quality Control option allows users to easily control and track the quality of their products.

- **Reference curve** – early detection of measurement errors
- **Material quality is kept under control** – tracking of characteristic material properties
- **Secure quality control** – electronic result transfer, storage and export functionalities

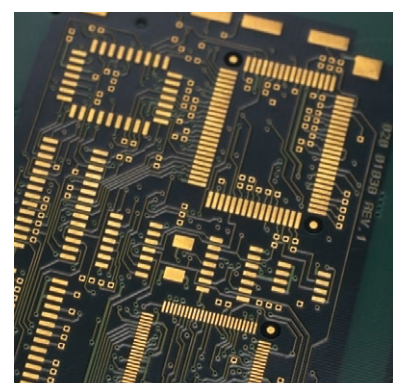


Extremely Wide Application Range

Thermal analysis is firmly established as a method for the characterization of physical and chemical properties of materials in many different fields.

Thermal analysis includes a number of different measurement techniques. Compared with other analytical methods, they offer the following advantages:

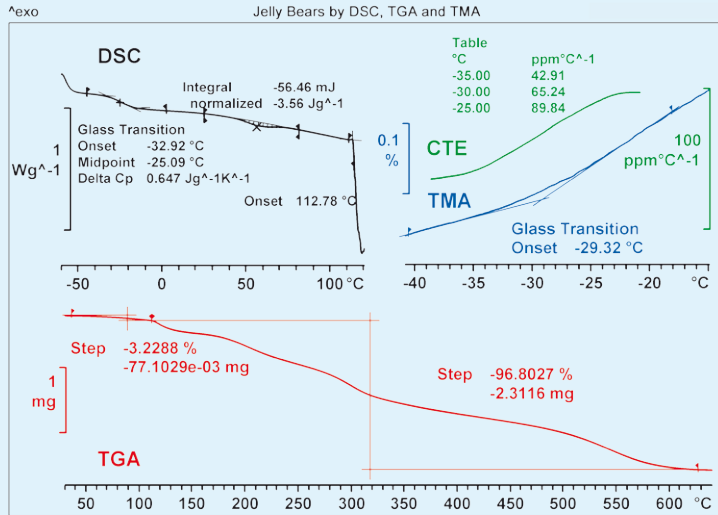
- easy sample preparation
- measurement of liquids, gels, powder, compact solids, fibers, thin layers, etc.
- very small samples
- easy operation
- short measurement times



Overview of possible fields of application

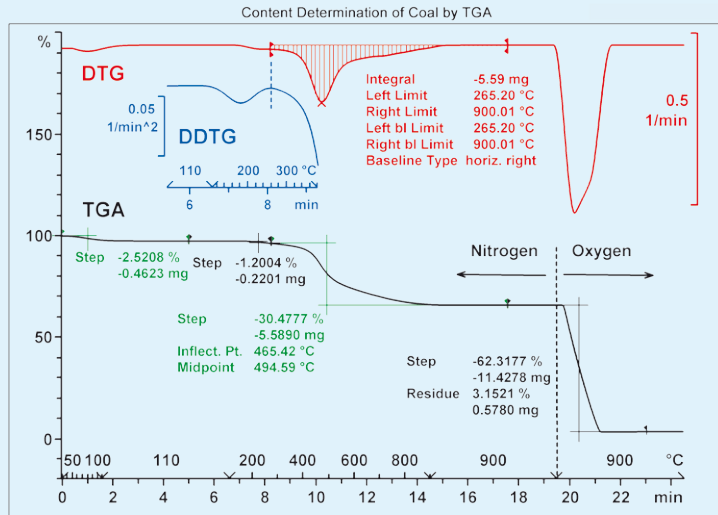
Materials characterization by:	DSC	FDSC*	TGA	TMA	DMA
Physical properties					
Melting / crystallization	•	•		•	•
Enthalpy of crystallization	•	•			
Solid fat index	•				
Purity determination	•				
Vaporization, drying	•		•		
Sorption and desorption			•		
Glass transition	•	•		•	•
Specific heat capacity	•	•			
Expansion coefficient, shrinkage behavior				•	
Polymorphism, crystalline transitions	•	•		•	
Liquid-crystalline transitions	•	•			
Viscoelastic behavior, elastic modulus				•	•
Chemical changes					
Decomposition, pyrolysis	•	•	•	•	
Oxidation, stability	•		•	•	
Curing, vulcanization, gelation	•				•
Dehydration	•		•		
Denaturation	•				
Swelling and foaming				•	
Reaction process, reaction enthalpy and kinetics	•	•	•		

*FDSC: Flash DSC



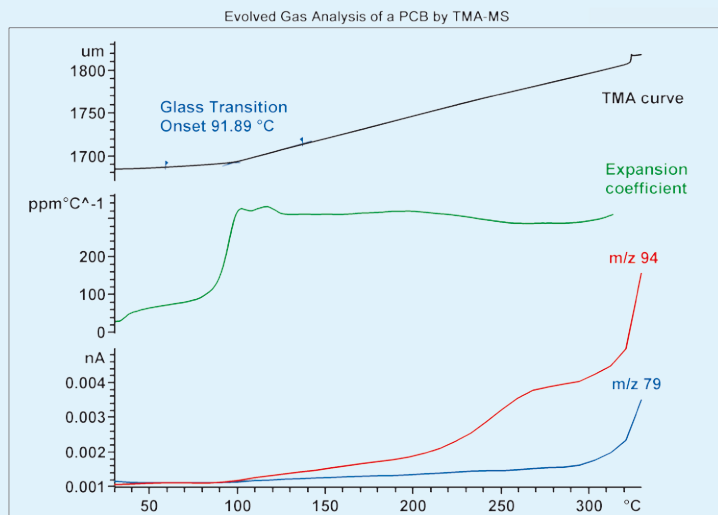
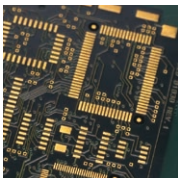
Curve display of different techniques

Materials are often characterized by several different thermal analysis techniques. The STAR[®] software can simultaneously display the resulting curves in one diagram. The example shows DSC, TGA and TMA curves from the measurement of a popular rubbery-textured type of candy. The DSC curve shows the glass transition and the vaporization peak of water. The TMA curve displays the glass transition and the expansion coefficient. The onset of thermal decomposition at higher temperature is apparent in the TGA curve.



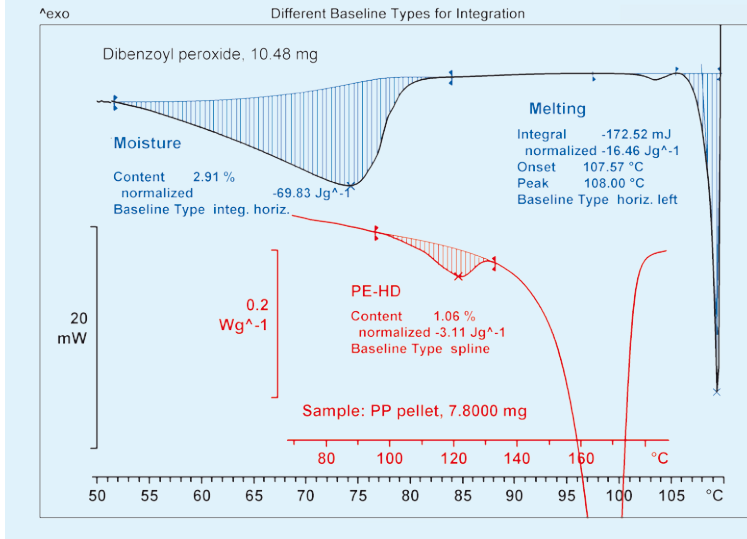
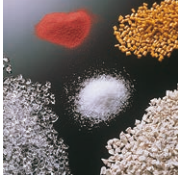
Content determination by TGA

Content analysis is one of the standard applications of TGA. The example shows the results from a coal sample analyzed according to ASTM E1131 for moisture content and for the content of volatile compounds and carbon. The sample was first heated to 900 °C in an inert atmosphere. This allows the moisture and volatile compounds to be determined. The atmosphere was then switched from nitrogen to oxygen. The carbon undergoes combustion, resulting in a further weight loss. The limits set for the individual weight loss steps are based on the first (DTG) and second (DDTG) derivatives of the weight loss curve.



Analysis of decomposition gases

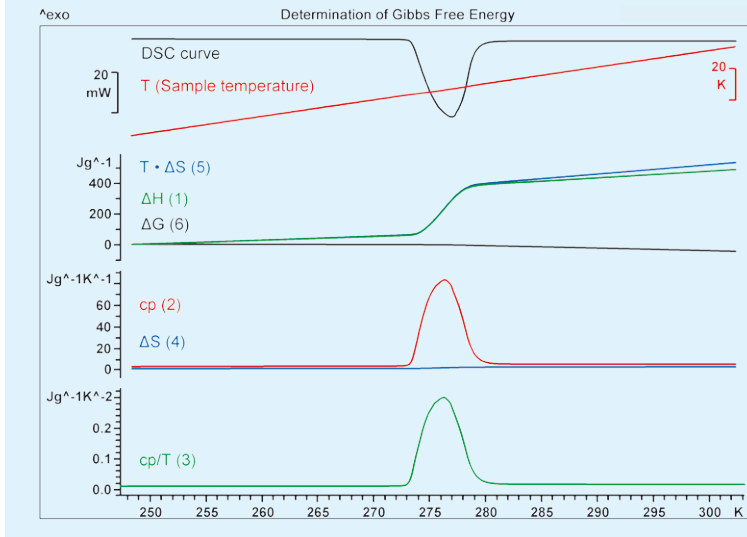
In thermal analysis, it is often important to determine the nature of the gases evolved when a material decomposes. This can be done by coupling the TGA or TMA to a gas analyzer such as an FTIR spectrometer or a mass spectrometer (MS). In this example, the thermal decomposition of a printed circuit board was studied using a TMA coupled online with a MS. The TMA curve shows the glass transition and the onset of delamination above 300 °C. The m/z 79 and m/z 94 fragment ion curves indicate the elimination of bromides and methyl bromides from a brominated flame retardant.



Different types of baseline

Choosing the right baseline is crucial for the integration and accurate determination of reaction or transition enthalpies. The STAR[®] software offers users a choice of nine different types of baselines.

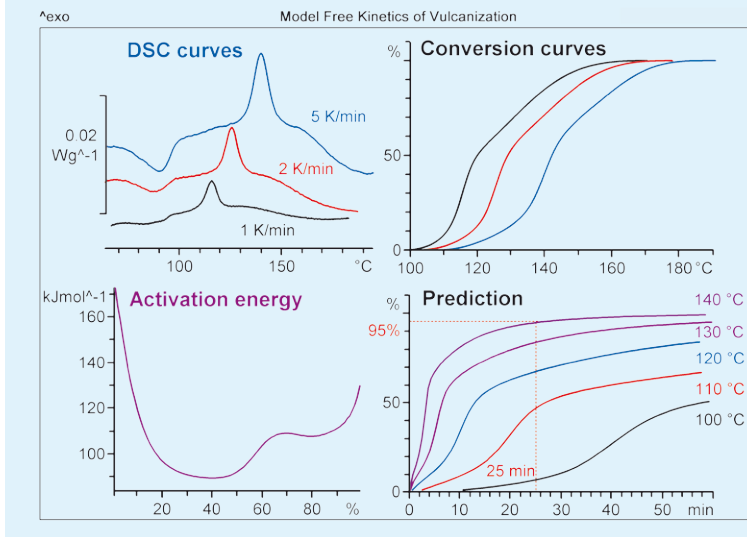
In an evaporation process (upper diagram, left peak), the sample mass and heat capacity change. This is taken into account by using an "integral" baseline. Dibenzoyl peroxide decomposes in the melt (black curve, right peak) and a "horizontal left" baseline is used to determine the enthalpy of melting. In the lower diagram (red curve), the PE-HD content in a blend of PE-HD and PP was determined using a "spline" baseline.



Curve calculations

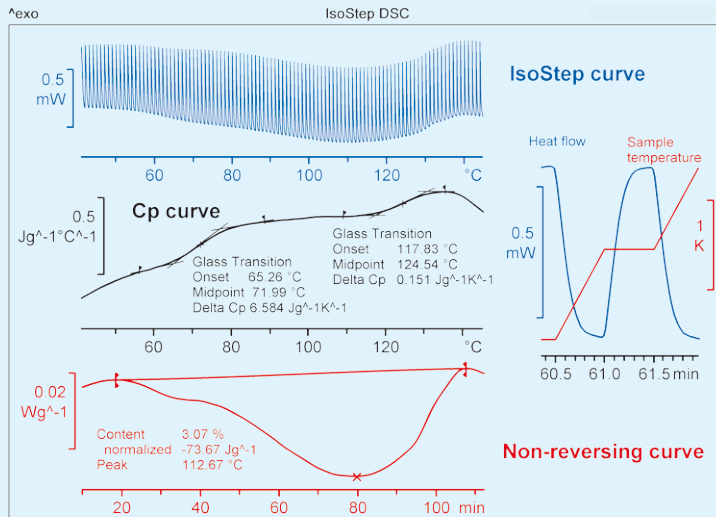
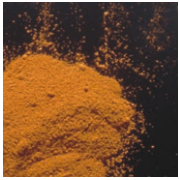
The example showing the determination of free enthalpy ($\Delta G = \Delta H - T \cdot \Delta S$) demonstrates that the STAR[®] software can be used to perform calculations on thermal analysis curves.

1. Enthalpy curve (ΔH)
2. Heat capacity curve (c_p)
3. c_p / T
4. $\Delta S = \int_{T_1}^{T_2} \frac{c_p}{T} dT$
5. $T \cdot \Delta S$
6. $\Delta G = \Delta H - T \cdot \Delta S$



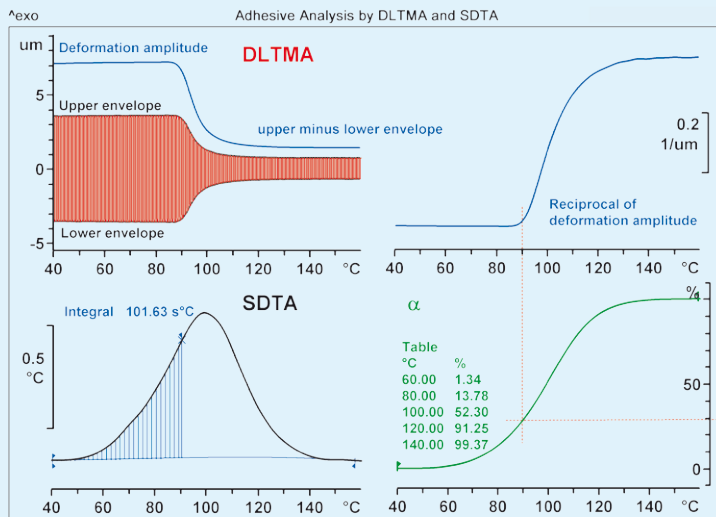
Kinetics of chemical reactions

The STAR[®] software can be used to predict and model chemical reactions in different ways. The example shows the vulcanization reaction of an NBR elastomer analyzed by model free kinetics. The method requires three separate DSC measurements to be performed at different heating rates. The software then uses the resulting conversion curves to calculate the activation energy for the reaction as a function of reaction conversion. This allows the conversion to be predicted as a function of time at different isothermal temperatures.



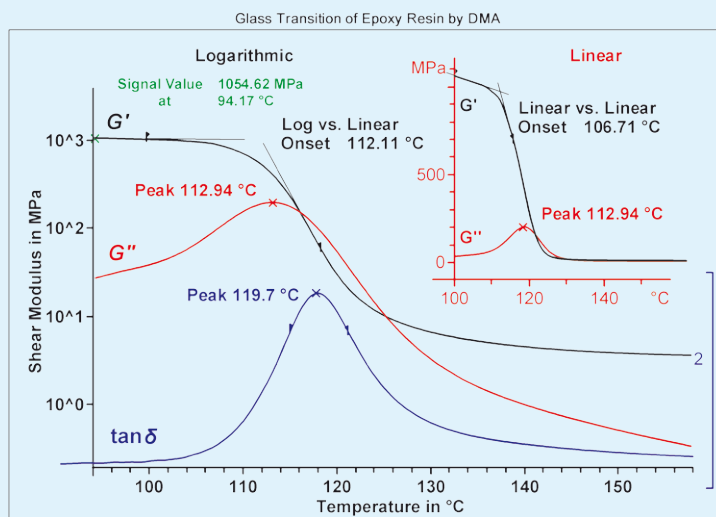
IsoStep temperature-modulated DSC

In the IsoStep technique, the temperature program consists of a series of alternating isothermal and heating segments. Typically, each segment lasts one minute (see inserted diagram, right). The heat capacity is determined from the dynamic segments, and the non-reversing heat flow from the isothermal segments. In the example, the specific heat capacity curve exhibits two glass transitions while the non-reversing heat flow curve shows the evaporation of moisture. This type of separation of different phenomena is only possible with temperature-modulated DSC techniques.



Curing of an adhesive by DLTMA

During a curing reaction, the liquid adhesive changes into a hard layer that fixes the parts together. If a liquid adhesive is applied to the underside of a razor blade, the curing process can be followed in a 3-point bending experiment using DLTMA (Dynamic Load TMA). The curing of the adhesive causes the sample to become stiffer. This leads to a decrease in the deformation amplitude in the DLTMA curve. In the SDTA curve, the curing process produces an exothermic peak. Comparison of the DLTMA and SDTA curves indicates that above 30% cure the mechanical properties of the adhesive change rapidly with increasing degree of cure.



DMA curve presentation

DMA experiments yield the complex modulus (M: Modulus, more specifically E: Young's modulus and G: Shear modulus), which is made up of the storage and loss moduli (M' and M''). The loss factor (tan δ) is also often calculated, which corresponds to the ratio of M'' to M'. The value of the glass transition temperature can be determined as the onset temperature of the step-like decrease in M', the peak temperature of M'', or the loss factor. It is important to note that the onset temperature of the storage modulus depends on the presentation of the curve: if M' is displayed linearly, the onset temperature is lower than when M' is displayed logarithmically.

Software Options and Their Requirements

Software options	Requires
Experiment Window	–
Server Mode	Concurrent User
Concurrent User	Server Mode
User Rights	–
21 CFR 11	–
LIMS	Experiment Window

Module option	
Routine Window	Simple methods and experiments

Method options	
Method Window	–
Conditional Experiment Termination	Method Window
MaxRes	Method Window

Evaluation options	
Reference Library	–
Mathematics	–
Quality Control	–
DSC Evaluations	–
Specific Heat	–
IsoStep®	Method Window
TOPEM®	Method Window and Experiment Window
TGA Evaluations	–
TMA Evaluations	–
DMA Evaluations	–
Kinetics nth order	DSC, TGA or TMA Evaluations
Model Free Kinetics	DSC, TGA or TMA Evaluations
Advanced Model Free Kinetics	DSC, TGA or TMA Evaluations

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Environmental management system according to ISO 14001.



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