DISCOVER THE WORLD’S FINEST THERMOMECHANICAL ANALYZER
DISCOVER a TMA that delivers
Superior Performance
Unmatched Sensitivity
Maximum Versatility
With the ever-increasing demands for higher performing materials to meet the needs of challenging applications, understanding how a material reacts to its environment is more important than ever. Meeting and exceeding industry standards* for testing, the Discovery TMA 450 provides information about the material’s coefficient of linear thermal expansion (CTE), shrinkage, softening, glass transition temperatures, and much more. The advanced options can be used to obtain viscoelastic properties such as the material’s stiffness (modulus), damping properties (tan delta), creep, and stress relaxation. The TMA 450 is particularly useful for measuring these material properties locally, especially in manufactured components or assemblies where compatibility of materials is paramount.

* ASTM E831, E1545, D696, D3386 and ISO 11359: Parts1-3

TA Instruments invites you to experience the finest in Thermomechanical Analyzers, the Discovery TMA 450. Discover the advanced engineering and attention to detail that provides enhancements in every aspect of performance and a new level of user experience. Featuring advanced testing capabilities and the widest range of fixtures, the Discovery TMA 450 is sure to meet and exceed your expectations.

**Features and Benefits:**

- Non-contact, friction-free motor delivers forces from 0.001 N to 2 N enabling measurements on the widest range of samples, from soft compressible elastomers to stiff composite materials.
- Wide-range, high-resolution measurement transducer accommodates sample lengths up to 26 mm and a measuring range of ±2.5 mm with resolution as low as 15 nm for an accurate dimensional change measurement.
- Advanced testing modes of Modulated TMA (MTMA™), Dynamic TMA, Creep and Stress Relaxation extend capabilities and empower users with even more valuable information about the mechanical behavior of materials.
- Convenient Mechanical Cooling Accessory (MCA 70) provides temperature control to -70°C without the cost or hassle of liquid nitrogen.
- Powerful Trio software delivers exceptional user experience and ease-of-use in a combined package for instrument control, data analysis, and reporting, reducing training times and raising productivity to new levels.
- New innovative, "app-style" touch screen puts instrument functionality simply One-Touch-Away™, enhancing usability and making it easier than ever to get great data.
- Every instrument comes with a commitment to quality backed by the industry’s ONLY five-year furnace warranty for peace of mind.
TA Instruments’ engineering experience in design allows us to seamlessly integrate critical furnace, dimension measurement, and atmosphere-control components, which meld with powerful TRIOS software to ensure configuration flexibility and maximum versatility on the Discovery TMA 450.

Furnace
The TMA 450 features a high-response low-mass furnace designed for the most precise control of temperature from -150°C to 1000°C and stable heating rates in the range of 0.1 to 100°C/min. The furnace ensures the superior baseline performance required for accurate dimension change measurements, as well as the dynamic temperature control required for Modulated TMA™ operation. The air-cool feature facilitates experiment turnaround times in as little as 10 minutes, significantly improving laboratory productivity. The integrated Inconel® 718 Dewar atop the furnace enables liquid nitrogen cooling to -150°C, or the instrument can be connected to the optional nitrogen-free Mechanical Cooling Accessory (MCA 70) for cooling to -70°C. In addition to a wider temperature range, cooling provides the ability to perform cyclic heating/cooling experiments, as well as further improving experiment turnaround times.

Sample Stage
The sample stage and probes are made of quartz and are optimized for an operational range of -150°C to 1000°C. Quartz is an ideal material because of its rigidity, inertness to corrosion, and very low thermal expansivity. The easily accessible stage simplifies probe or fixture installation, sample mounting, and thermocouple placement. The quartz probes are designed to be used in expansion, penetration, flexural (3-point bend) and tension modes of deformation. An integrated dual-input gas module provides purge gas atmosphere (air, argon, helium, or nitrogen) to the sample area to a maximum flow rate of 200 mL/min.

High Performance Displacement Transducer
At the heart of the TMA 450 is a displacement transducer, which directly measures sample dimension change with great precision and accuracy over a wide displacement and temperature range (-150 to 1000°C).

The measurement system provides 15 nm resolution and ±2.5 mm dynamic range for samples up to 26 mm in length. The displacement transducer is isolated from temperature drift ensuring stable baseline performance and repeatability.

Friction-Free Force Motor
A non-contact motor provides a friction-free controlled force to the sample over a range of 0.001 to 1 N. The force can be increased to 2 N by addition of weights.

The precision control of the force motor generates the static, ramped, or oscillatory dynamic forces necessary for quality measurements in all deformation modes. From standard temperature ramps using a controlled force, to small amplitude dynamic TMA, the Discovery TMA 450 is outfitted to capture a broad spectrum of material properties with the highest level of sensitivity and accuracy.
Expansion measurements determine a material’s coefficient of thermal expansion (CTE), glass transition temperature (T_g), and compression modulus. A flat-tipped standard expansion probe is placed on the sample (a small static force may be applied), and the sample is subjected to a temperature program. Probe movement records sample expansion or contraction. This test is used with most solid samples. The larger surface area of the macro-expansion probe facilitates analysis of soft or irregular samples, powders, and films, and the volumetric fixture allows the determination of volumetric coefficient of thermal expansion.

Penetration measurements use an extended tip probe to focus the drive force on a small area of the sample surface. This provides precise measurement of glass transition (T_g), softening, and melting behavior. It is valuable for characterizing coatings without their removal from a substrate. The probe operates like the expansion probe, but under a larger applied stress. The hemispherical probe is an alternate penetration probe for softening point measurements in solids.

Tensile studies of the stress/strain properties of films and fibers are performed using a film/fiber probe assembly. An alignment fixture permits secure and reproducible sample positioning in the clamps. Application of a fixed force is used to generate stress/strain and modulus information. Additional measurements include shrinkage force (T_g), softening temperatures, cures, and crosslink density. Dynamic tests (e.g., Dynamic TMA, Modulated TMA™) in tension can be performed to determine viscoelastic parameters (e.g., E’, E”, tan delta), and to separate overlapping transitions.

3-Point Bending
In this bending deformation (also known as flexure), the sample is supported at both ends on a two-point quartz and atop the stage. A fixed static force is applied vertically to the sample at its center via a wedge-shaped quartz probe. This test is considered to represent “pure” deformation, since clamping effects are eliminated. It is primarily used to determine bending properties of stiff materials (e.g., composites) and for distortion/temperature measurements. Dynamic measurements are also available with the TMA 2050EM, where a special low-friction metallic anvil replaces the quartz version.
Expansion, Macro-Expansion, & Volumetric Accurate Coefficient of Thermal Expansion Measurements

This example demonstrates the use of the expansion probe to accurately measure CTE changes in an aluminum sample over a 200°C temperature range. TRIOS software permits analysis of the curve slope using a variety of methods to compute the CTE at a selected temperature or over a range.

Penetration & Hemispherical Softening Temperature (Tg) Determination

The penetration fixture was used to test polycarbonate/acylonitrile-butadiene-styrene (PC/ABS), an amorphous thermoplastic blend, at a controlled heating rate of 5°C/min and a constant force of 0.2 N. Conditions outlined in ASTM D150 and ISO 11359 were followed in the assignment of the softening temperature/glass transition by penetration. The softening points are easily detected as a negative deflection in dimension change, and individual softening points were observed for each component of this blend.

Tension Fiber Stress/Strain Measurements

Stress/strain measurements are widely used to assess and compare materials. The figure to the right the different regions of stress/strain behavior in a 25 mm polyamide fiber in tension, subjected to a force ramp at a constant temperature. The fiber undergoes an instantaneous deformation followed by retardation, then a linear stress/strain response, and finally yield elongation. Other parameters (e.g., yield stress, Young’s modulus) can be determined.

3-Point Bending Material Performance and Selection

The figure to the left is an example of a 3-point bending test (flexure probe) experiment on a polyvinyl chloride (PVC) sample using the ASTM International Test Method D2992 to determine the distortion temperature or “deflection temperature under load” (DTUL). The test specifies the temperature at which a sample of defined dimensions produces a certain deflection under a given force. It has long been used for predicting material performance.
The ALL NEW TMA 450 RH is a stand-alone instrument that allows for controlled relative humidity experiments over both wide temperature and RH ranges. Measure CHE, CTE*, track Tg changes, and perform dynamic experiments, all under a controlled RH environment.

Features and Benefits:

- Broadest range of RH and Temperature of any instrument on the market (See graph below).
- Widest range of all expansion quartz fixtures providing industry-leading baseline flatness for superior dimension change measurements.
- Non-contact, friction-free motor delivers forces from 0.001 N to 2 N enabling measurements on the widest range of samples.
- Advanced models for dynamic, creep, stress relaxation, or isostress experiments.
- Powerful TRIOS software combines instrument control, data analysis, and reporting in an integrated package to deliver an exceptional user experience.
- Innovative, “app-style” touch screen enhances usability by putting instrument functionality simply One-Touch Away™.

The TMA 450 RH includes the following:

1. Fully engineered and integrated sample chamber specifically designed to provide the most precise temperature and humidity controlled environment on the market.
2. The TMA RH Accessory that contains the gas humidifier and controls the flow of humidified gas to the sample chamber.
3. A heated vapor transfer line connecting the TMA RH Accessory to the sample chamber. The transfer line is maintained above the vapor dew point for transfer of the vapor without condensation.

* Over temperature range of 5 – 120°C

** Discovery TMA RH Specifications

- Temperature Range: 5 – 120 °C
- Temperature Precision: ±0.1 °C
- Heating/Cooling Rate: 0.1 – 1 °C/min
- Humidity Range: 5 – 95% (see chart)
- Humidity Accuracy: 5 – 90% ±3%; >90 – 95% ±5%
- Humidity Ramp Rate: 0.1 – 2 %RH/min
- Maximum Sample Size: 26 mm
- Measurement Precision: ±0.1%
- Sensitivity: 15 nm
- Force Range: 0.001 – 2 N
- Frequency Range: 0.01 – 2 Hz
Assessing CHE
The expansion or swelling of a material due to water uptake is dependent on the material's coefficient of hygroscopicity (CHE). The plot to the right measures this property for Kapton, an important polyimide used in the electronics industry. The plot is a sorption isotherm produced from a stepped humidity experiment. Also shown is the calculated CHE between successive points.

Detecting Tg
Glass transitions are sensitive to water uptake, as the water acts as a plasticizer. Detecting and tracking changes in Tg are critical to material function and storage. The plot to the right shows the Tg of a gelatin used in pharmaceutical drug capsules captured with a RH ramp of 2%/min at 37 and 50°C. At higher temperatures, the Tg is shifted to lower RH levels due to higher water uptake and resultant plasticization.

Comparing Hygroscopicity
Perfluorosulfonic Acid (PFSA) films, also known as proton exchange membranes, are used extensively in new battery technology. Many advanced polymers must be tested for responses to humid conditions. The plot to the right the comparison of the hygroscopicity of commercial film compared against the Kapton data above. The PFSA film has approximately an order of magnitude larger response to humidity than the Kapton.

Shrinking on Drying
Many materials shrink while drying, and it is important to be able to understand the forces involved. In the plot on the right, a polymer film is held under isostress conditions of 0.2% and the force necessary to maintain the strain is tracked during a rapid change in humidity from 50% to 0%. The increase in force necessary to maintain the strain constant is clearly measured.
Touch Screen Features and Benefits:

- Ergonomic design for enhanced accessibility and productivity
- Packed with functionality to simplify instrument operation
- Resilient, responsive touch screen for an enhanced user experience

The One-Touch-Away™ interface includes:

- Start/stop controls
- Real-time signals and plot
- Active method viewing
- Temperature settings
- Probe and force calibrations
- Probe position and sample measurement settings
- System information
- Test and instrument status

The app-style touch screen, powerful new TRIOS software, and quick robust calibration routines work seamlessly to dramatically improve laboratory workflows and productivity.

The Discovery TMA 450 features TA’s innovative touch screen, making operation easier than ever with enhanced One-Touch-Away™ functionality.
TRIOS Features:

- Control multiple instruments with a single PC and software package
- Overwrite and compare results across techniques including TMA, DMA, DSC, TGA, SDE and rheometers
- Unlimited licenses and free lifetime software upgrades
- One-Click analysis for increased productivity

Ease of Use

TRIOS software makes calibration and operation of the TMA 450 simple. Users can easily generate multiple calibration data sets under varying experimental conditions (e.g. different heating rates or gas selections) and seamlessly switch between them to match the experimental conditions used for sample testing. The progress of running experiments is readily available, with the added capability of modifying a running method on the fly. TRIOS software offers a level of flexibility that is unmatched in the industry.

Complete Data Record

The advanced data collection system automatically saves all relevant signals, active calibrations, and system settings. This comprehensive set of information is invaluable for method development, procedure deployment, and data validation.

Quick & Easy Calibration

TRIOS software makes calibrating the sample fixtures/probes and the TMA 450 effortless. Clear instructions, available on both the touch screen and TRIOS software, guide the operator through simple calibration steps that end with a summary report. The report provides calibration status at a glance and is stored with each data file to ensure data integrity.

Complete Data Analysis Capabilities

A comprehensive set of post-test reports are available for real-time data analysis, even during experiments. Gain actionable insights into your material behavior through a powerful and versatile set of features seamlessly integrated into TRIOS.

Standard SIA Analyses:

- Alpha at X1 (CTE)
- Alpha at X1 to X2 (CTE)
- Alpha fit X1 to X2 (CTE)
- Onset and endset analysis
- Dimension change (absolute and %)
- Step transition
- Curve values at specific X or Y points
- 1st and 2nd derivatives
- Mathematical fitting: straight line, polynomial, or exponential
- Stress and strain curves

Advanced Analysis Capabilities on the TMA 450EM:

- Storage and loss modulus, with tan delta peak analysis when using Dynamic TMA
- Deconvolution of the Total Dimension Change signal with Modulated TMA™ (MTRM™) into Reversing and Non-Reversing dimension change signals for separating expansion from contraction, shrinkage and stress relaxation

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Thermomechanical analysis (TMA) measures material dimensional changes under controlled conditions of force, atmosphere, time, and temperature. In the typical operation of a TMA, a small sample with parallel and flat surfaces is placed on a quartz stage near a thermocouple. A quartz probe is lowered against the specimen with a constant applied force. As the sample is heated or cooled, changes in dimension are measured by monitoring the motion of the quartz probe.

Meeting and exceeding industry standards for testing, the Discovery TMA 450 provides information about the material’s coefficient of linear thermal expansion (CTE), shrinkage, softening, glass transition temperature, heat deflection, and much more.

Advanced tests expand the capabilities of the Discovery TMA 450 to enable scientists and engineers to get the most out of their data and their instrument investment.

**Standard Tests include:**
- Temperature Ramp
- Force Ramp
- Isostrain
- Custom Edited Procedure

**Advanced Tests (Enhanced Mode—EM) include:**
- Stress Ramp
- Strain Ramp
- Creep
- Stress Relaxation
- Modulated TMA (MTMA™)
- Dynamic Temperature Ramp (Force Modulation)
- Manual (a combination of advanced test types)

*ASTM D696, D3386 and ISO 11359: Parts 1-3

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### The POWER of TMA

**TMA is critical for understanding compatibility of materials that must function together. Examples include:**
- Coatings and their substrates
- Adhesive layers or laminates or fibers
- Seals, or encapsulants, and the mechanical systems they protect

**TMA helps determine the suitability of materials for use in harsh environments and at extreme temperature. Examples include:**
- Brake linings
- Automotive gaskets
- Creep
- Window seals
- Solder joints
- Adhesives
- Protective coatings

*ASTM E831, E1545, D696, D3386 and ISO 11359: Parts 1-3

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**Typical properties and behaviors measured by the TMA include:**
- Linear thermal expansion
- Coefficient of thermal expansion (CTE)
- Phase transition temperatures
- Glass transition temperatures
- Shrinkage or contraction
- Softening points
- Volumetric expansion
- Delamination
- Residual cure reactions
- Stress
- Decomposition temperature

**Advanced TMA tests provide:**
- Storage and loss moduli (E', E'')
- Damping properties (tan delta)
- Relaxation behavior
- Creep and recovery
- Stress relaxation
- Stress-strain curves
- Shrink force
- Decomposition of simultaneous expansion and shrinkage
**Standard Operational Tests**

TMA measures material deformation changes under controlled conditions of force, atmosphere, time, and temperature. Force can be applied in compression, flexure, or tensile modes of deformation using specially-designed probes. TMA measures intrinsic material properties (e.g., expansion coefficient, glass transition, Young’s modulus), plus processing/product performance parameters (e.g., softening point).

These measurements have wide applicability and can be performed on either the Discovery TMA 450 or TMA 450EM. The TMA 450 features a Standard set of tests (temperature ramp, force ramp, and isostrain), while the TMA 450EM additionally offers Stress/Strain, Creep, Stress Retardation, Dynamic TMA, and Modulated TMA™.

**Intrinsic and Product Property Measurements**

The figure shows expansion and penetration probe measurements of the Tg and the softening point of a synthetic rubber using a temperature ramp at constant applied force. The large CTE changes in the expansion plot indicate the transition temperatures. In penetration, the transitions are detected by the sharp deflection of the probe into the sample.

**Shrinkage Force Testing**

The figure illustrates a classic shrinkage force (isostrain) experiment on a food wrapping film. The film was strained to 20% at room temperature for 5 minutes, cooled to -50°C and held for more than 5 minutes, then heated at 5°C/min to 75°C. The plot shows the force variation (shrinkage force) required to maintain a set strain in the film. This test simulates film use from freezer to the microwave.

**Temperature Ramp | Monitor Displacement or Strain**

Force is held constant and displacement is monitored under a linear temperature ramp to provide intrinsic property measurements.

**Isostrain | Monitor Force**

Strain is held constant and the force required to maintain the strain is monitored under a temperature ramp. This test assesses shrinkage forces in materials such as films/fibers.

**Force Ramp | Monitor Displacement or Strain**

Force is ramped and resulting strain is measured at constant temperature to generate force/displacement plots and modulus assessment.
Coefficient of Thermal Expansion

The most common property measured on a TMA is the coefficient of thermal expansion (CTE) per international standards documented in ASTM E831, D969, D3380 and ISO 11359 Parts 1-3. The CTE describes the mechanical expansion or contraction of a material at different temperatures. It is an important property of a material, and neglecting to take into account the effect temperature has on the physical size of materials has been known to cause product failures and delamination. The mean coefficient of thermal expansion (CTE) is calculated as:

\[ \alpha = \frac{1}{L_0} \frac{\Delta L}{\Delta T} \]

where \( \alpha \) is the mean coefficient of thermal expansion, \( \Delta L \) is the expansion of the specimen (mm) over a specified temperature range, \( L_0 \) is the initial specimen length (mm), and \( \Delta T \) is the temperature change (ºC) through the test. The CTE of a material is temperature dependent, and \( \alpha \) is a reported mean for a particular temperature range.

Distortion Temperature in 3-Point Bending

Ideal Deflection Temperature (IDT) and Distortion Temperature Under Load (DTUL) are equivalent items that reflect the temperature at which a material subjected to a 3-point bending load deforms to a predefined position. The actual force applied to the sample and the amount of deflection required depend upon the sample geometry.

ASTM standard D293, and a related standard D684, define DTUL as the temperature at which a precise strain (either 0.25 mm deflection or 0.20% strain as defined by sample dimensions in the procedure) occurs under a specific stress (either 455 or 1820 kPa). With the TMA, the loads (force) needed to achieve these stresses can be determined using the equation listed below.

\[ F = \frac{2}{3} \frac{Sbd^2}{L} \]

where \( F \) is the force (N), \( S \) is stress (0.455 MPa [66 psi] or 1.82 MPa [264 psi]), \( b \) is the sample width (mm), \( d \) is the sample thickness (mm), and \( L \) is the sample length (5.08 mm as defined by the flexure probe geometry).

The deflection of the test specimen is recorded as a function of temperature at which the predetermined level of strain is observed. The deflection or dimension change is determined using the relationship in the equation shown below.

\[ D = \frac{rL^2}{6d} \]

where \( D \) is the TMA dimension change at center span (mm) and \( r \) is Sample strain (0.0020 or 0.20%).

Deflection temperature under load (DTUL) testing is easily conducted on the Discovery 450 TMA. Polystyrene, polyethylene, and polysulfone were tested by using the three-point flexure probe with a 0.455 MPa (66 psi) load 0.25% strain, and 2°C/min heating. The DTUL measurements of these materials are illustrated on a plot of temperature and deflection at a load of 0.455 MPa. The CTE of a material can be modified through reorientation with compatible resins and fiber reinforcement (DTUL tests with small specimens are quick and easily conducted on the Discovery TMA 450).

Calculated values for experimental force and dimensional change at center span when using conditions of 0.455 MPa stress, 0.2% strain, and a heating rate of 2°C/min.
**Advanced Operational Tests**

Advanced testing capabilities include TA's industry-leading Modulated TMA® for the most efficient separation of simultaneous expansion and contraction of a material. Dynamic TMA for viscoelastic properties by small amplitude, fixed-frequency sinusoidal deformation, and Creep/Stress Relaxation for viscoelastic behavior under transient conditions. These advanced options empower scientists and engineers with even more valuable information about the mechanical behavior of materials.

**Stress/Strain Tests**

Stress or strain is ramped, and the resulting strain or stress is measured at a constant temperature. Using customer-entered sample geometry factors, the data provides both stress/strain plots and related modulus information. In addition, calculated modulus can be displayed as a function of stress, strain, temperature, or time.

**Film Tensile Testing**

The figure to the right displays a strain ramp experiment at a constant temperature on a polymeric film in tension. The plot shows an extensive region where stress and strain are linearly related, and over which a tensile modulus can be directly determined. Quantitative modulus data can also be plotted as a function of stress, strain, time, or temperature. The results show the ability of the TMA 450EM to function as a mini tensile tester for films and fibers.

**Creep and Stress Relaxation**

TMA can also measure viscoelastic properties using transient (creep or stress relaxation) tests. In a creep experiment, input stress is held constant, and resulting strain is monitored as a function of time. In a stress relaxation experiment, input strain is held constant, and stress decay is measured as a function of time. The data can also be displayed in units of compliance (creep test) and stress relaxation modulus (stress relaxation test).

**Creep Analysis**

Creep tests are valuable in materials selection for applications where stress changes are anticipated. This example illustrates an ambient temperature creep study on a polystyrene film. In tension, it reveals the instantaneous deformation, retardation, and linear regions of strain response to the set stress, plus its recovery with time at zero stress. The data can also be plotted as compliance, and recoverable compliance, versus time.

**Stress Relaxation Analysis**

This figure shows a stress relaxation test in tension on the same polyethylene film used for the creep study in the previous example. A known strain is applied to the film and maintained while its change in stress is monitored. The plot shows a typical decay in the stress relaxation modulus. Such tests also help engineers design materials for end uses where changes in deformation can be expected.
Modulated TMA™ (MTMA™)

This industry-leading Modulated TMA™ efficiency separates simultaneous expansion and contraction in a material. Through deconvolution of the total dimensional change, an event such as the glass transition occurring in the same temperature region as stress relaxation is easily revealed. In Modulated TMA, the sample experiences the combined effects of a sinusoidal temperature oscillation overlaid on the traditional linear ramp. The output signals (after Fourier transformation of the raw data) are total displacement and the change in thermal expansion coefficient. Modulated TMA separates the total displacement into Reversing and Non-Reversing dimensional change signals. The reversing signal contains events attributable to dimension changes and is useful in detecting related events such as the Tg. The non-reversing signal contains events that relate to time-dependent kinetic processes (e.g., stress relaxation). This technique is unique to the TA Instruments Discovery TMA 450EM.

Dynamic TMA Tests

In Dynamic TMA (DTMA), a sinusoidal force and linear temperature ramp are applied to the sample (Figure A), and the resulting strain amplitude and sine wave phase difference (δ) are measured (Figure B). From this data, storage modulus (E') and loss modulus (E'') are calculated as functions of temperature, time or stress (Figure C). Dynamic TMA enables the scientist or engineer to obtain the viscoelastic behavior of materials.

Separating Overlapping Transitions - Modulated TMA

The figure to the right shows an MTMA study to determine the Tg of a printed circuit board (PCB). The signals plotted are the total dimensional change, plus its reversing and non-reversing components. The total signal is identical to that from standard TMA, but does not uniquely define the Tg. The component signals, however, clearly separate the actual Tg from the stress relaxation event induced by processing conditions of the PCB.

Viscoelastic Property Determination - Dynamic TMA

This figure illustrates a dynamic test in which a semi-crystalline polyethylene terephthalate (PET) film in tension is subjected to a fixed strain amplitude force during a linear temperature ramp. The resulting strain and phase data are used to calculate the material's viscoelastic properties (e.g., E', E'' and tan δ). The plotted data show dramatic modulus changes as the film is heated through its glass transition temperature.
Take advantage of the convenient Mechanical Cooling Accessory, the MCA 70, for unattended TMA and Modulated TMA (MTMA™) operation over a broad temperature range. The MCA 70 is ideal for cyclic heating/cooling experiments that are increasingly being used by manufacturers to test materials under conditions of actual use.

Temperature Cycle Testing (TCT) determines the ability of parts to withstand extremely low and high temperatures and cyclical exposures to these extremes. A mechanical failure resulting from cyclical thermomechanical loading is known as a fatigue, so temperature cycling primarily accelerates fatigue failures. The MCA 70 makes it easier than ever to study a material’s response to extreme changes in temperature.

MCA 70 Features and Benefits:
- Two-stage refrigeration system that provides a temperature range of -70°C to 400°C
- Sealed system eliminates the need for liquid nitrogen cooling
- Enables cycling, Modulated TMA, controlled, and ballistic cooling experiments
- Safe, convenient, and continuous cooling operation for your laboratory needs

Performance Specifications

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<th>Specifications</th>
<th>Discovery TMA 450EM</th>
<th>Discovery TMA 450</th>
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<td>Temperature Range (min-max)</td>
<td>-180 to 1000°C</td>
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<td>Frequency Range</td>
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