

Extended Material
Characterization



Use your rheometer for...

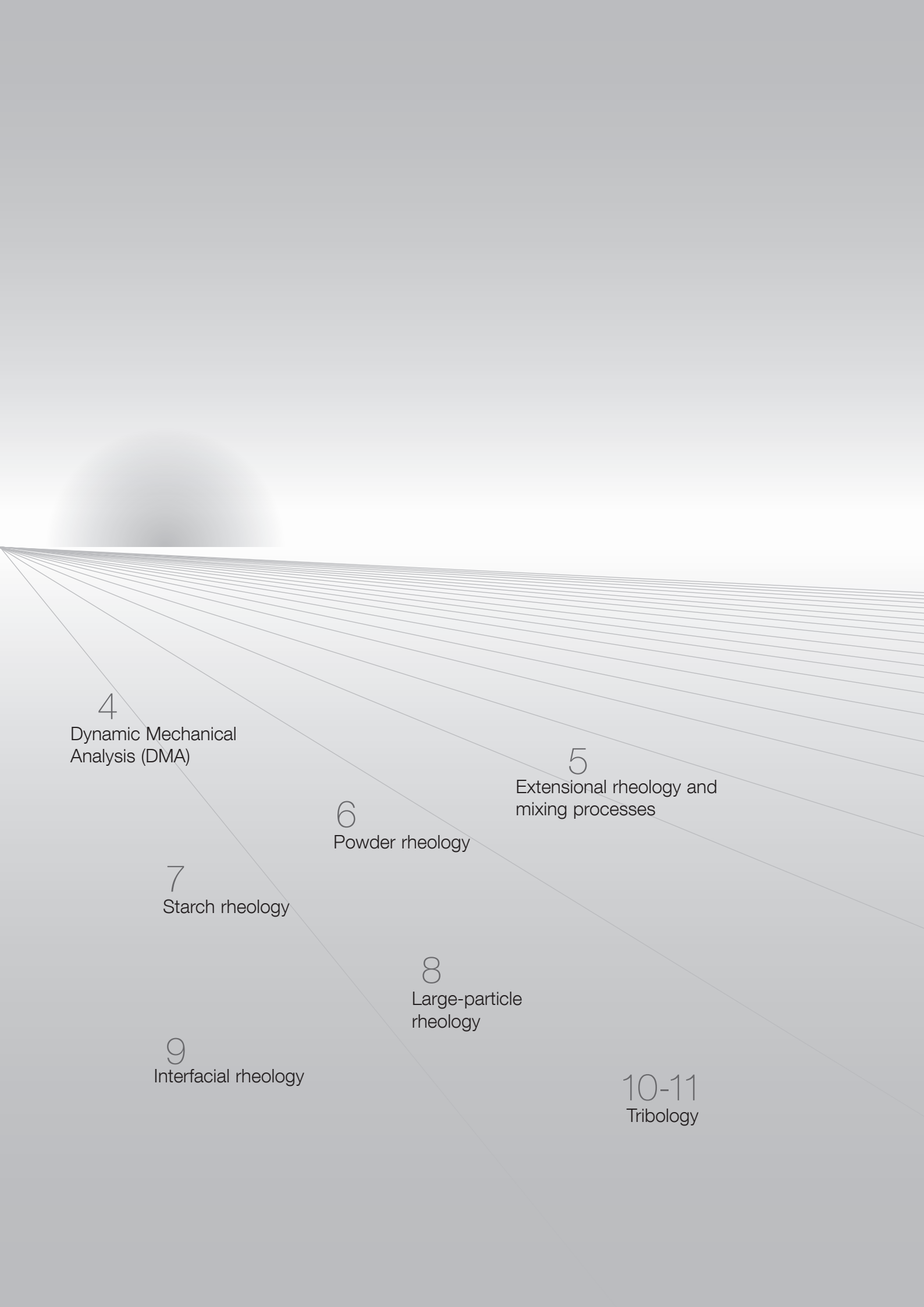
Extended Material Characterization



MCR rheometers offer you an open range of possibilities – and this range does not stop at shear rheology.

A comprehensive selection of easily integrated accessories transfer the capabilities of the intrinsically modular MCR series into other material characterization applications. Patented features ensure the convenient, reliable exchange and configuration of any application-specific accessory.

The choice is yours: Whether you want to perform DMTA analysis in torsion or extension, interfacial rheology, tribology or more – the dynamic performance, high sensitivity and low-torque capabilities of MCR rheometers are at your service.



4

Dynamic Mechanical
Analysis (DMA)

5

Extensional rheology and
mixing processes

6

Powder rheology

7

Starch rheology

8

Large-particle
rheology

9

Interfacial rheology

10-11

Tribology

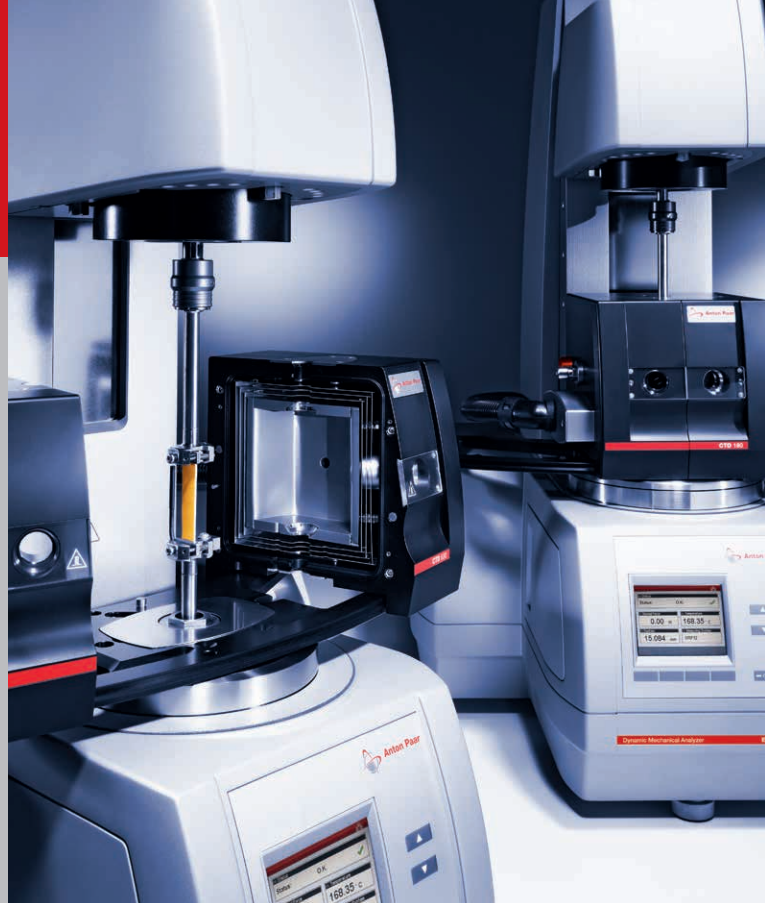
Use your rheometer for... Dynamic Mechanical Analysis (DMA)

Fixtures for films, rectangular and circular solids

MCR rheometers can also be used for Dynamic Mechanical Analysis (DMA). The temperature and mechanical behavior of films, fibers and solids is investigated with a variety of available fixtures such as solid circular or rectangular fixtures (SCF, SRF), film and fiber fixtures (UXF) or parallel-plate systems.

The large temperature range of the CTD convection temperature devices allow you to characterize materials from the glassy to the molten state. Consequently, materials' transition temperatures and relaxations are precisely determined.

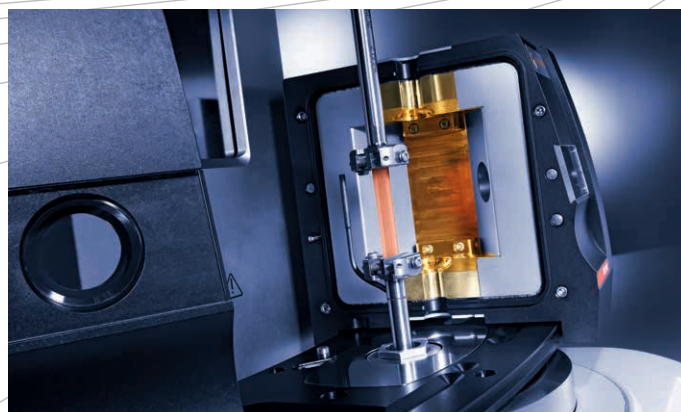
The humidity option for the convection oven device CTD 180 enables DMA measurements under controlled temperature and humidity conditions and prevents sample drying.



Solid Rectangular or Circular Fixtures (SRF, SCF)

MCR rheometers can be used for Dynamic Mechanical Analysis in torsion. The temperature and mechanical behavior of solids is investigated with a variety of available fixtures such as solid circular or rectangular fixtures (SCF, SRF). The solid rectangular fixture is available for single- and twin-drive systems.

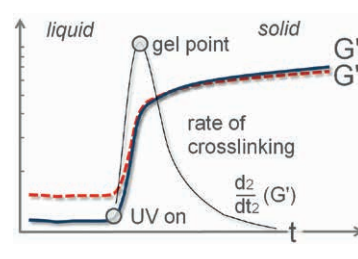
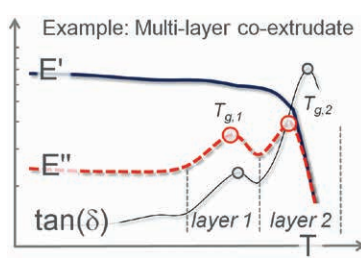
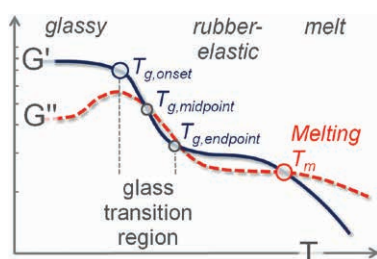
The large temperature range of the CTD convection temperature devices allows you to characterize materials from the glassy to the molten state. Consequently, materials' transition temperatures and relaxations are precisely determined.



Universal Extensional Fixture (UXF)

The Universal Extensional Fixture (UXF) can be used for Dynamic Mechanical Analysis in tension on films and fibers.

In combination with an MCR rheometer and a CTD convection temperature device, the UXF enables tensile strain- or stress-controlled DMA tests across a wide temperature range. This combined system is used to investigate effects such as temperature stability, shrinkage, elongation, crystallizations, phase transitions, relaxations and the brittleness of films and fibers.



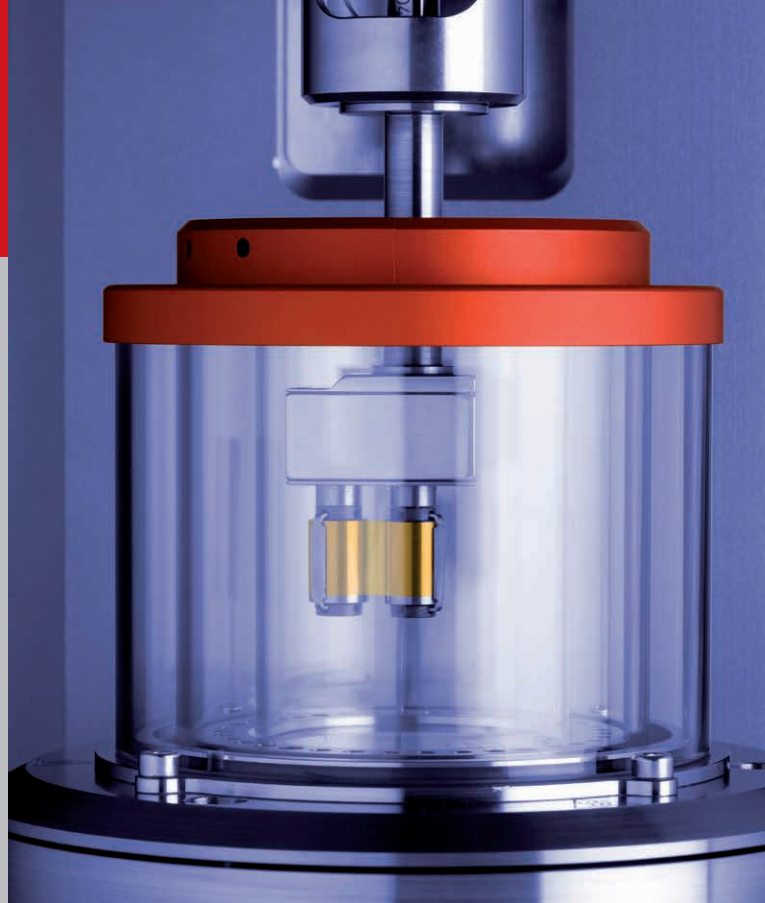
Use your rheometer for...

Extensional rheology

Elongation tests for film and fibers

Elongational viscosity functions and optimization can play a crucial role in product planning. Elongational tests can be used for product control, product research and for the structure determination of competitive products. Using extensional measurements at all stages of development, the behavior of polymers with branching structures will increase understanding and product security.

Combined with the convection temperature devices, this setup enables extensional tests, e.g. tests on synthetic polymers, biopolymers or tissues, across a wide temperature and deformation range.



Sentmanat Extensional Rheometer (SER)

The Extensional Rheometer System developed by Dr. Martin Sentmanat turns your MCR rheometer into a universal testing platform for extensional rheology.

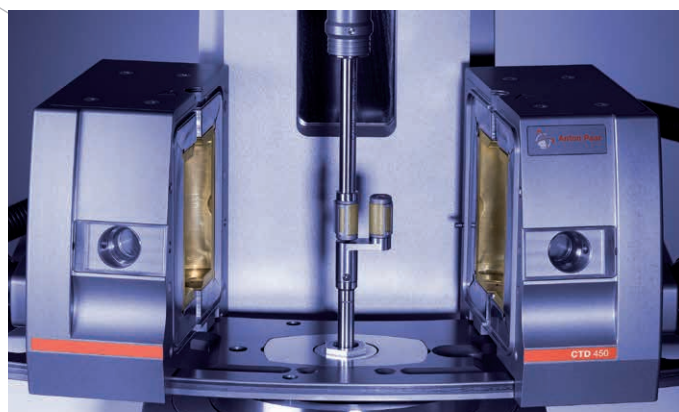
The setup consists of two drums which are connected to the rheometer. While one drum is driven directly by the shaft, the second is connected via gears and turns in the opposite direction. This setup can be immersed into a fluid to prevent potential sample sagging. Besides characterizations in extension, the SER system can be used for solid tensile, tear, peel and friction testing.



Universal Extensional Fixture (UXF)

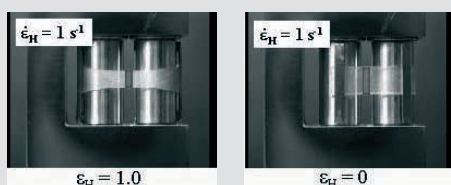
The UXF for single-drive is a universal extensional fixture. It is used for oscillatory measurements (DMA in tension) as well as rotational measurements for measuring the extensional viscosity of melts.

UXF TwinDrive is the extensional test with best low torque sensitivity but not suitable for oscillatory measurements.

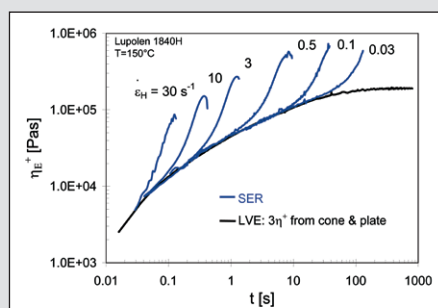


Application	SER	UXF	UXF TD
Extensional rheology	++	+	++
Oscillation measurements (DMA tension)	-	++	+

LDPE measured at different Hencky strain rates compared to cone-plate measurements in oscillation:



Visualization of an extensional experiment on a polyolefin melt



Use your rheometer for... Powder rheology

Powder Cell

The Powder Cell turns an MCR rheometer into a powder rheometer and brings the full array of traditional rheological methods to the field of powder.

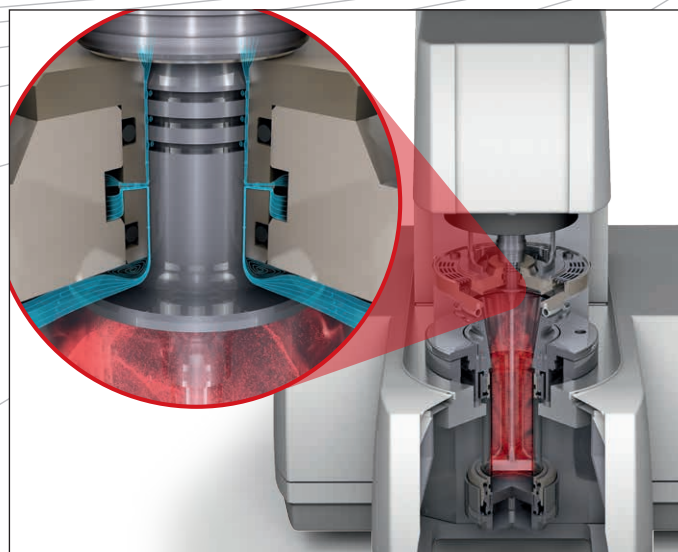
It enables quality control for true powder rheology in an easy, reliable and extraordinarily reproducible way by giving a value which indicates deviations in powder flow. No matter what has caused the changes (particle size and shape, chemical structure, humidity, packing behavior, static charge, surface morphology, gas adsorption, etc.), it is represented by this value: Cohesion Strength!

In the field of advanced true powder rheology the amazing precision achieved with MCR rheometers is brought to the field of granular media. The powder rheometer enables both rotational and oscillatory tests in any state of either consolidation or fluidization and also includes a high-precision pressure-drop device.

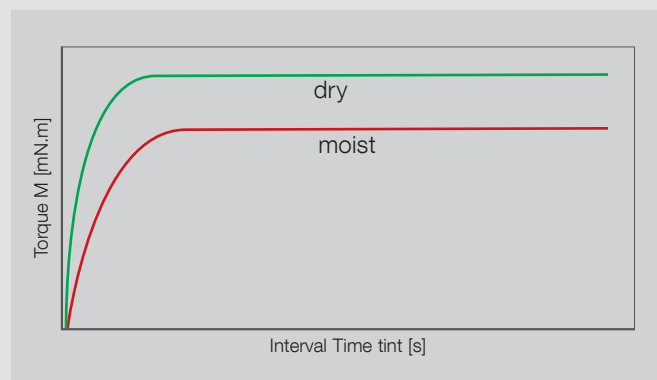


Unique dust protection

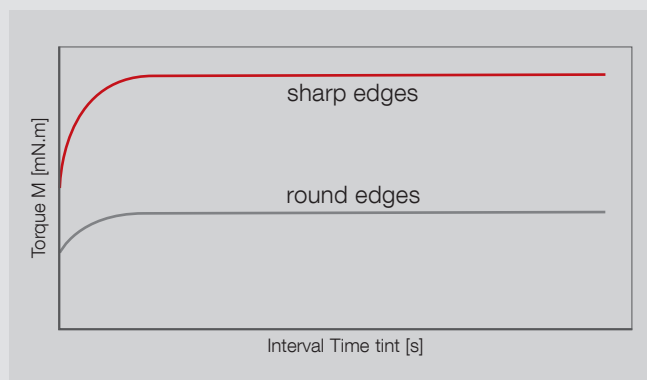
The Powder Cell's unique dust protection hood safeguards the operator and the instrument from fine and potentially hazardous powder even when the powder is fully fluidized. By combining the air-seal technology and a two-fold geometric barrier, the Powder Cell is one hundred percent dustproof without any friction on the measurement axis and therefore retains the MCR rheometer's extraordinary accuracy and resolution down to 10 nNm and below.



No matter which factor influences your powder, the established Cohesion Strength value will change:



Even a small amount of moisture can influence the flow behavior to a large degree



The shape of your particles can and will influence the flow behavior (same particle size)

Use your rheometer for... Starch rheology

Starch Rheology System

The Starch Rheology System turns your MCR rheometer into a platform for the analysis of starch pasting behavior at elevated pressure and temperature conditions.

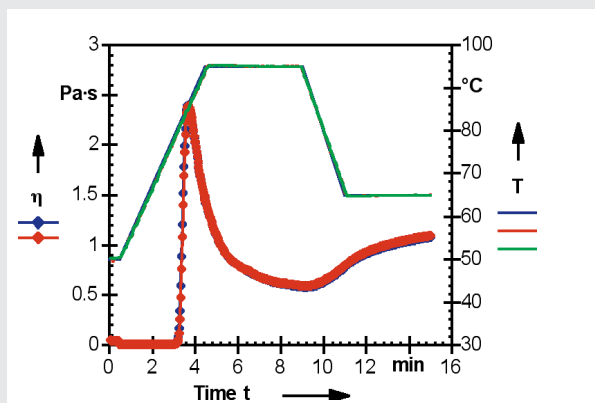
The high heating and cooling rates required for starch gelling measurements are achieved by combining electrical heating with fluid-circulator-supported cooling. A special stirrer prevents sedimentation in the liquid phase.

The system can be used for starch tests under ambient pressure at up to 95 °C and, equipped with a specific pressure cell (max. 30 bar), even allows rapid sample cooking up to 160 °C. Any real process condition, such as food sterilization, can be simulated based on tailor-made test programs.

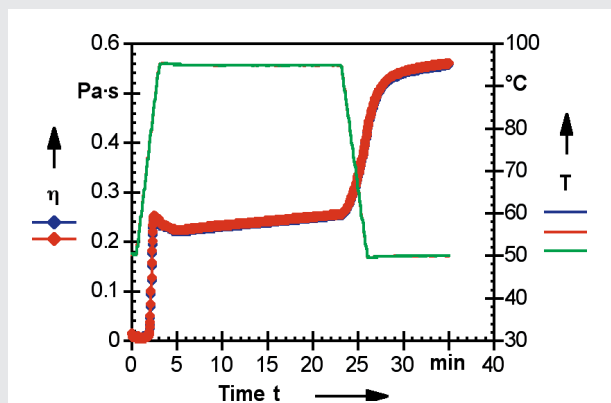


Easily customized and automated workbook templates with pre-defined heating, holding and cooling intervals simplify your measurement setup and provide all required starch analysis results such as the gelation temperature, peak viscosity and final viscosity.

The two examples below illustrate the Starch Rheology System's reproducibility for starch testing.



Gelation of dent corn starch



Gelation of modified waxy corn starch

Use your rheometer for... Large-particle rheology

Building Material Cell

The Building Material Cell (BMC) is specially designed for rheological measurements on building materials with large particles, providing information on processability, shelf life and flowability.

Building materials are often pastes or highly filled suspensions containing large particles with sizes up to 5 mm. They show tendencies of wall slippage or separation when sheared with conventional measuring systems. The BMC's special vane and cup design eliminates this risk; its modular inset cages with flow breakers prevent wall slippage and improve mix-up effects.

The Peltier-temperature-controlled cell is abrasion-proof and easy to clean, since all wetted surfaces are made of stainless steel. It is easily adapted to all MCR rheometer models and can be used in all rheological test modes: controlled shear rate (CSR), controlled shear stress (CSS) and oscillatory testing.

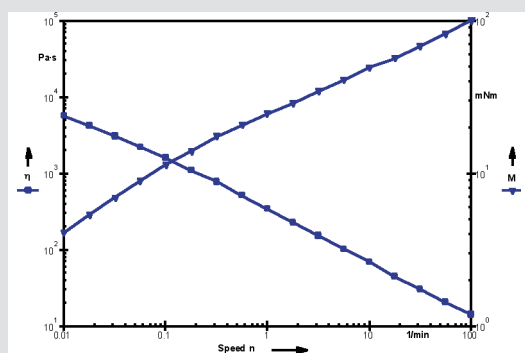
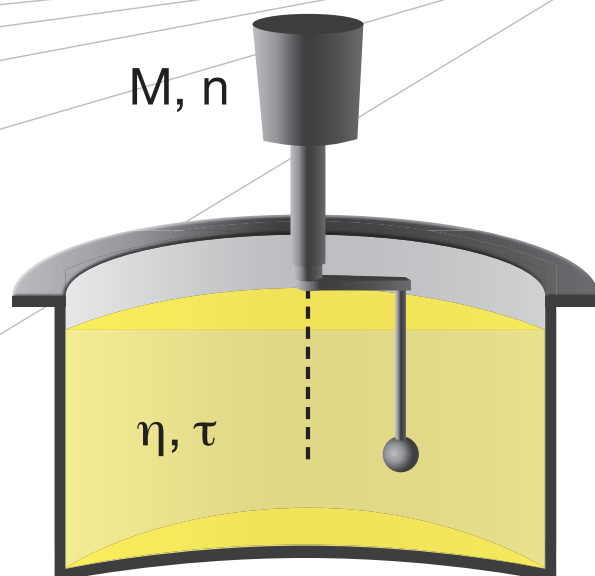


Ball Measuring System

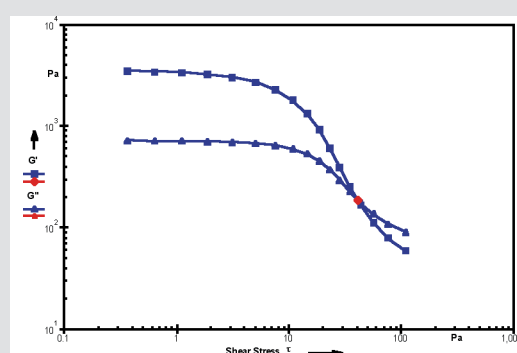
The Ball Measuring System (BMS) is used in combination with an MCR rheometer to measure the flow properties of samples with very large particles.

The system is based on a principle by Mueller-Tyrach which involves an excentrically rotating sphere. This sphere is available in various diameters depending on your samples' viscosity. Due to the outstanding speed control of the MCR series' EC motor, a full flow and viscosity curve can be determined in one single revolution of the measuring system.

The flow properties of large-particle samples such as slurries, sludges or food products can be determined within one single rotation; dimensionless analysis of the produced flow field allows the online calculation of rheological parameters such as viscosity and shear rate.



Flow curve of silica plaster measured with the BMC



Amplitude sweep of silica plaster measured with the BMC

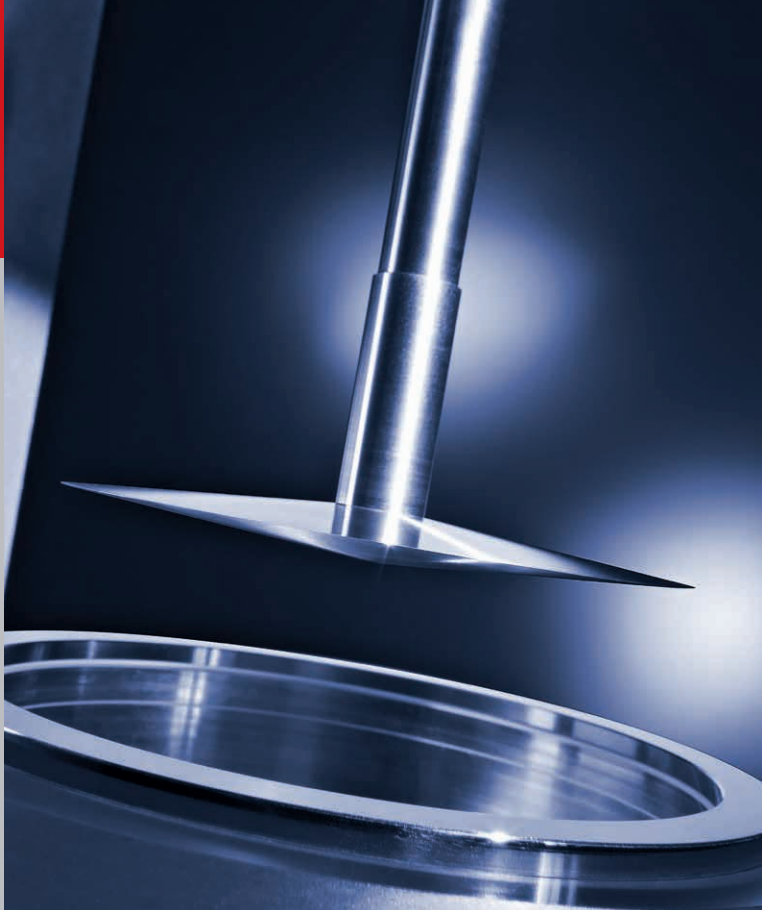
Use your rheometer for...

Interfacial rheology

Interfacial Rheology System

The Interfacial Rheology System (IRS) combined with an MCR rheometer enables two-dimensional rheological measurements of interfacial films at the air/liquid and the liquid/liquid interface.

In the IRS, a bi-cone measuring system is placed in the interface and measures absorbed or spread films, e.g. films produced by proteins or surfactants. Employing the low-torque capabilities and the TruStrain™ feature of the MCR rheometer, the IRS enables rheological measurements of weakest interfacial structures.



The temperature is controlled by Peltier elements in the range from 5 °C to 70 °C; the patented normal force sensor in the air bearing of the MCR rheometer allows the accurate positioning of the bi-cone in the interface.

A post-processing hydrodynamic flow field analysis subtracts the contribution of the bulk and covering phase and calculates the relevant interfacial properties of the measured interfacial layer.

Measurements can be performed in rotational and oscillatory mode, e.g. allowing flow curves and creep tests at an interfacial layer or oscillatory tests during the film formation process.

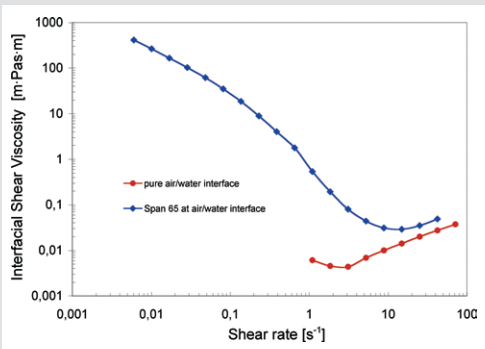
All measured and calculated interfacial data is recorded and displayed in the MCR series' application software, in which pre-defined interfacial rheology workbooks are available for user-friendly operation.

Specifications Interfacial Rheology System

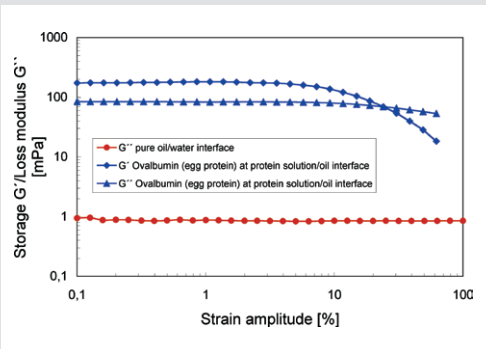
Measuring geometry	Bi-cone with radius of 34.14 mm and bi-cone angle of 10° (2 x 5°)
Temperature	5 °C to 70 °C
Accessory	P-PTD 200/80/I
Software	Interfacial Flow Field Analysis

Specifications sample

Spread interfacial film	Sample dissolved in solvent
Absorbed interfacial film	Sample dissolved in the bulk liquid
Covering phase	Air or fluid



Air/liquid interface



Liquid/liquid interface

Use your rheometer for... Tribology

Accessories for tribological measurements are specially designed to put the MCR rheometers' precision in motion and force control to the best possible use.

You can use this unique setup to complement rheological and DMTA measurements. Stribeck curves, static friction tests (including break-away torque) and specific motion profiles combined with normal force and temperature control provide information one step closer to the application.

Test the performance of a broad range of applications from the characterization of lubricants (oil, greases) to materials and coatings (metals, polymers, ceramic) and component tests (bearings or the like).



MCR 302/502/702	T-PID/44	T-PTD 200		T-BTP
Measuring principle	Pin-on-disk	Ball-on-three-plates	Rolling bearing test	Ball-on-three-plates
Normal force $F_{N,Tribo}$	0.7 N to 17 N	1 N to 23 N	1 N to 50 N	0.1 N to 23 N
Sliding speed v_s	10^{-9} m/s to 2.3 m/s	10^{-8} m/s to 1.4 m/s (3.3 m/s ⁻¹)	-	10^{-8} m/s to 1.4 m/s
Revolution U	10^{-6} rpm to 1000 rpm	10^{-6} rpm to 3000 rpm		
Torque M	MCR 302: 1 nNm to 200 mNm MCR 502 TDR: 1 nNm to 230 mNm MCR 702 TD: 1 nNm to 230 mNm MCR 502 S: 50 nNm to 300 mNm			
Temperature T	-30 °C to 190 °C	-40 °C to 200 °C		CTD 180: -20 °C to 180 °C CTD 450 TDR: -150 °C to 450 °C
Deflection angle φ	1 μ rad to ∞ μ rad			

Customized solutions

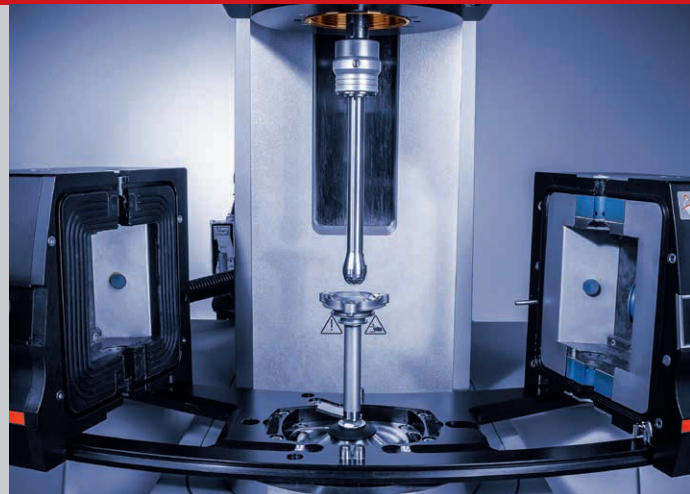
For your specific application in the broad field of tribology, not covered by the current accessories, Anton Paar offers customized solutions. Benefit from the high precision of the Anton Paar workshop and the creative heads of our development and engineering department. We customize sample holders as well as partial or complete measuring setups to meet your specific needs.

Please contact Anton Paar: tribo@anton-paar.com

T-BTP

Extended atmosphere control for ball-on-three-plates

- ▶ Employ advantages of CTD temperature control for tribological measurements
- ▶ Temperature control between -150 °C and 450 °C
- ▶ Humidity control 5 % to 95 %
- ▶ Spring stiffness adjustable in z-direction



T-PID/44

High precision motion control pin-on-disc

- ▶ Full flexibility, high precision motion control
- ▶ Spring stiffness adjustable in z-direction
- ▶ For tribological characterization of lubricants and materials



T-PTD 200

Tribology with full motion flexibility and precision

- ▶ **Range of measuring setups:**
 - Ball-on-three-plates (1/2" ball, 30 mm ball)
 - Sample holder for different specimen geometries
 - Rolling bearing test setup
- ▶ **Exceptional motion precision in rotation and oscillation**
 - Deflection angles down to 1 μ rad
 - Speeds as low as 10^{-9} m/s
 - For ball-on-three-plates and ball bearing test setup
- ▶ **Superior temperature control**
 - Temperature range: -40 °C to 200 °C
 - Application of Peltier control



