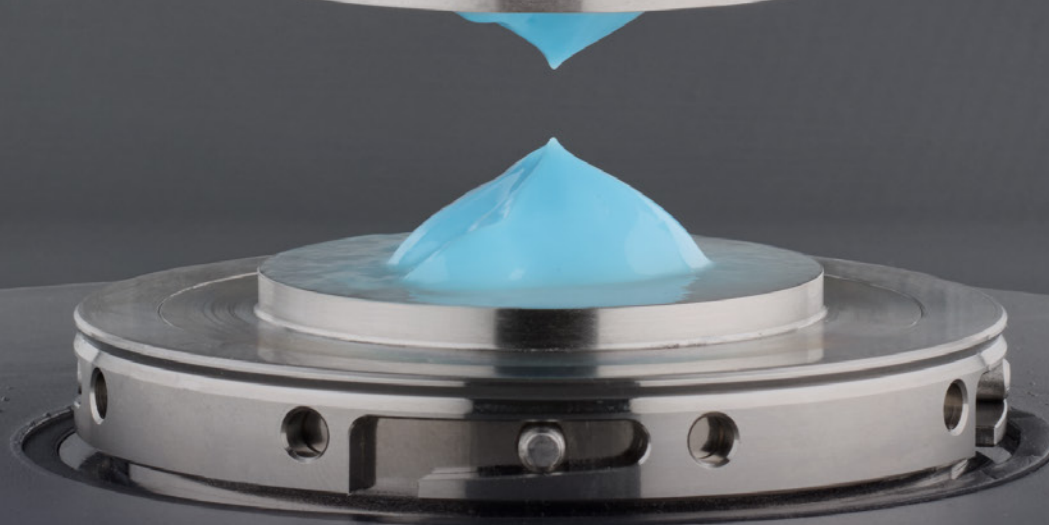


Waters™



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DISCOVERY CORE RHEOMETER

INTRODUCING the DISCOVERY CORE RHEOMETER

The new Discovery™ Core Rheometer empowers every user to perform rheological measurements, guiding formulation development, optimizing performance and ensuring product quality. The Core Rheometer is the first system to combine wide-ranging measurements of viscosity and viscoelasticity with streamlined, walk-up usability. The new RheoGuide™ user interface enables complete operation directly from the touchscreen, with direction, illustration and validation at every step.

Whether you are new to rheology, upgrading your quality control testing, or expanding capabilities to meet growing demands, the Core Rheometer empowers your lab to discover insights into your materials' behavior needed to advance your goals.

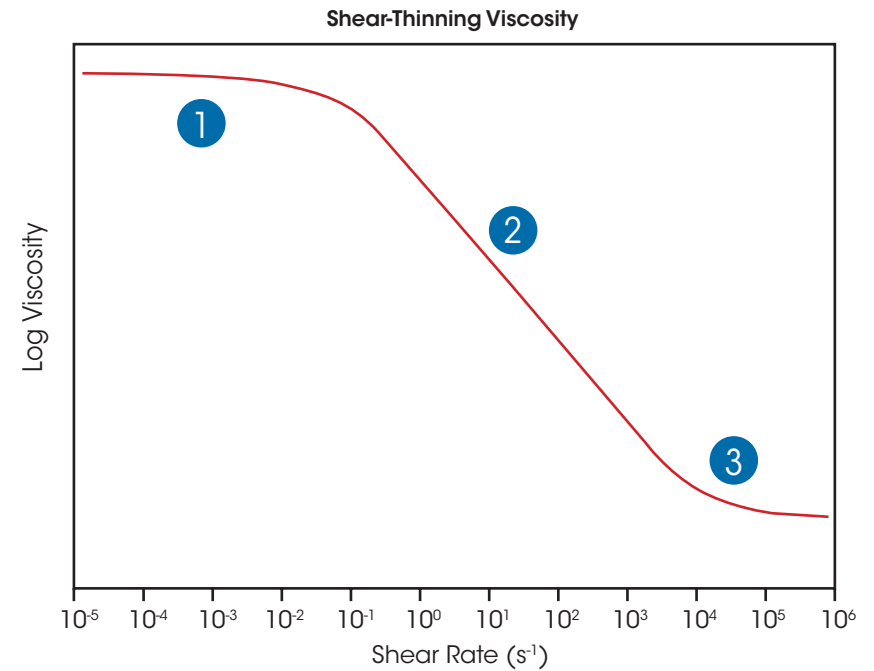


DISCOVER INSIGHTS beyond VISCOSITY

While viscometers report only a single viscosity value within a limited range, the Core Rheometer captures the complete viscosity profile, representing material behavior across all relevant conditions. Complex fluids like suspensions, emulsions, gels, pastes and slurries are non-Newtonian. Their viscosity changes with the applied shear rate and time; it is not a single value. Characterizing the full range of viscosity is critical to understand flow behavior under real-world conditions.

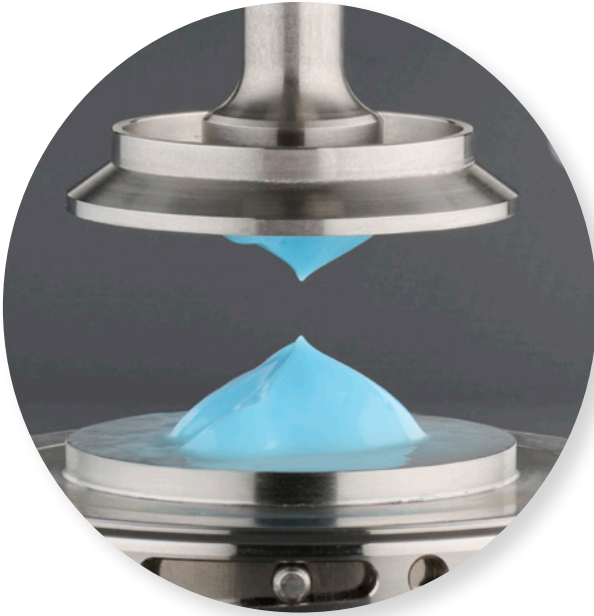
Rheometer Advantages:

- Accuracy and precision
- Range of measurement
- Controlled shear rate
- Replicate process conditions
- Small sample volume
- Rapid temperature control



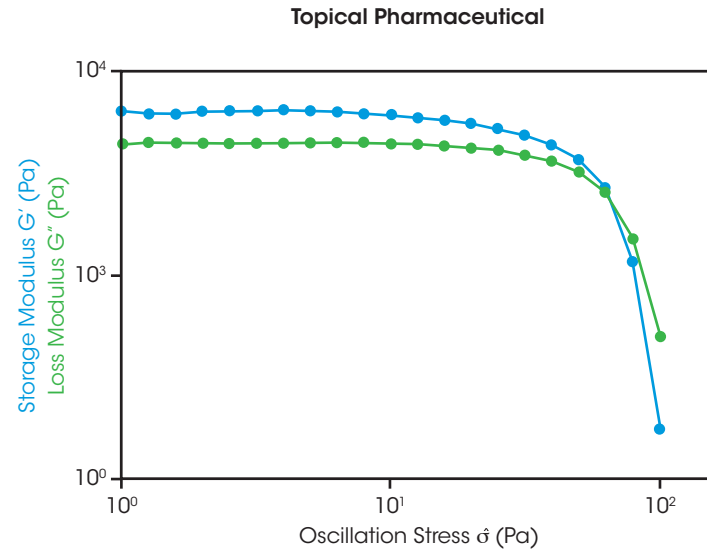
- 1** High viscosity at low shear rates impacts sag and leveling of coatings and maintains uniform distribution in dispersions by preventing separation under gravity during storage.
- 2** With increasing shear rate, viscosity decreases. This enabling easy dispensing whether by pouring from a can, pumping through a pipe or squeezing from packaging.
- 3** High shear rates replicate applications such as coating onto a substrate or spreading a topical product on the skin, ensuring successful processing and consumer experience.

DISCOVERY CORE RHEOMETER | VISCOELASTICITY



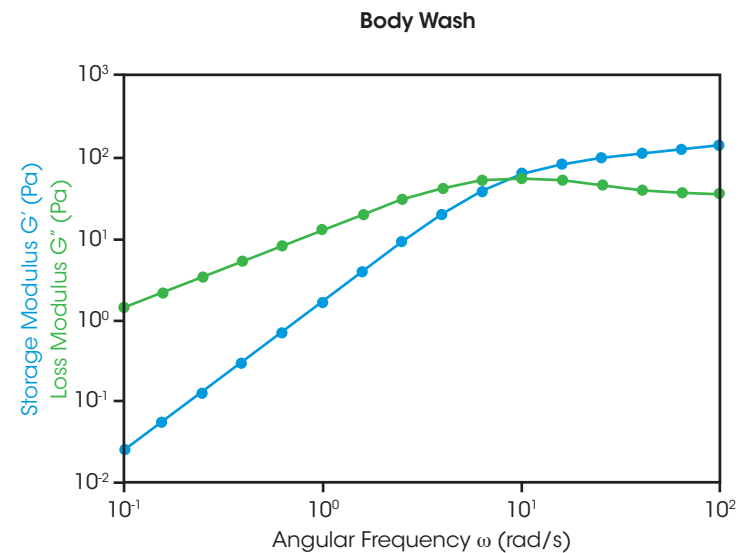
Materials ranging from weakly structured dispersions to stiff gels or pastes exhibit both liquid-like and solid-like behavior, not available from traditional viscometry.

The Core Rheometer's oscillatory measurements quantify viscoelasticity - Storage Modulus G' (elastic behavior), Loss Modulus G'' (viscous behavior) and $\tan \delta$ (damping). These key metrics aid in optimizing formulations, evaluating stability, and ensuring consistency in production.



Amplitude

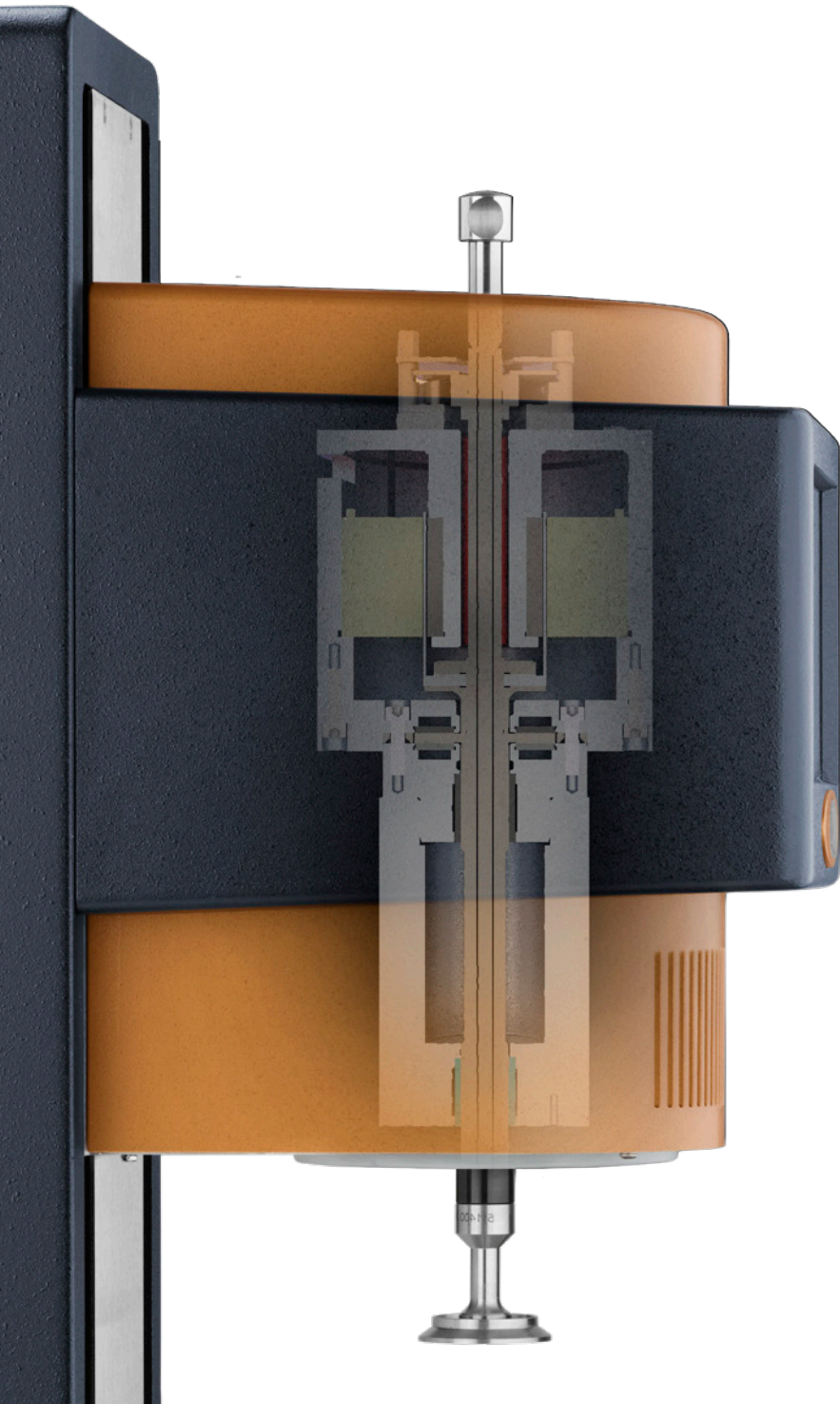
In this plot, a topical ointment measured with low stress in the linear viscoelastic region shows solid-like behavior ($G' > G''$). Increasing stress causes the ointment to begin to flow, indicating a yield stress of 66 Pa, key information for ensuring effective dispensing, spreading and stability.



Frequency

Varying the oscillatory frequency characterizes viscoelasticity over different time scales. A liquid soap exhibits fluid-like behavior ($G'' > G'$) at rest, but under very short time scales, elastic behavior dominates ($G' > G''$). This impacts a consumer's experience and can only be quantified using oscillatory rheology.

DISCOVERY CORE RHEOMETER | CORE MEASUREMENT TECHNOLOGY



Precision air bearings

Air bearings eliminate the mechanical friction of ball bearing designs, extending torque sensitivity down to $0.3 \mu\text{N.m}$ for flow measurements, and $0.1 \mu\text{N.m}$ for oscillation measurements.

The Core Rheometer's torque sensitivity enables measurements of viscosities as low as 1 cP, low shear rates and yield stresses, and viscoelasticity of weakly-structured fluids.

Optical encoder

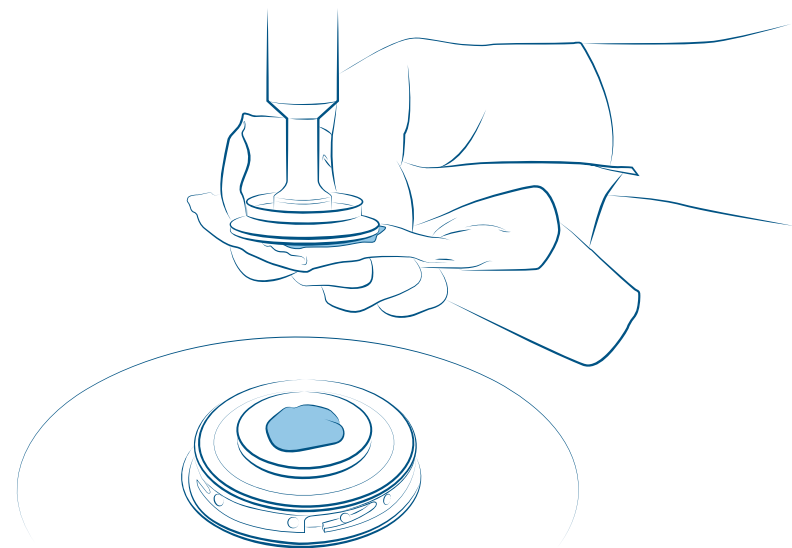
Precisely measure rotational velocity (Shear rate) and angular deformation (Strain)

Drag cup motor

Flexibility to perform shear rheology in controlled stress, rate or strain modes

Robust design

Streamline operations and expedite workflow with the Core Rheometer: safely clean liquid samples in place, without the need to remove tools from the rheometer.

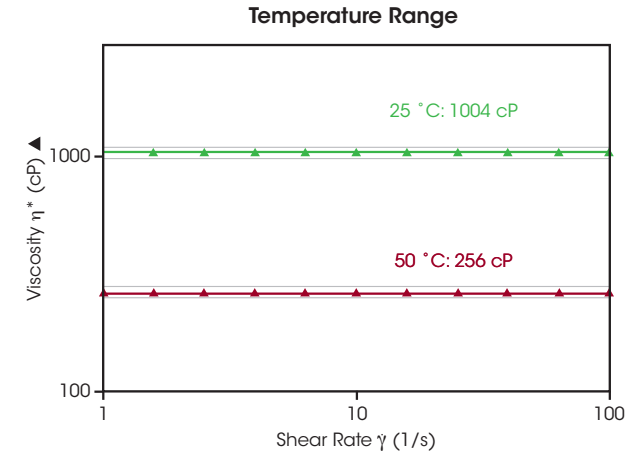


DISCOVERY CORE RHEOMETER | CORE TEMPERATURE TECHNOLOGY

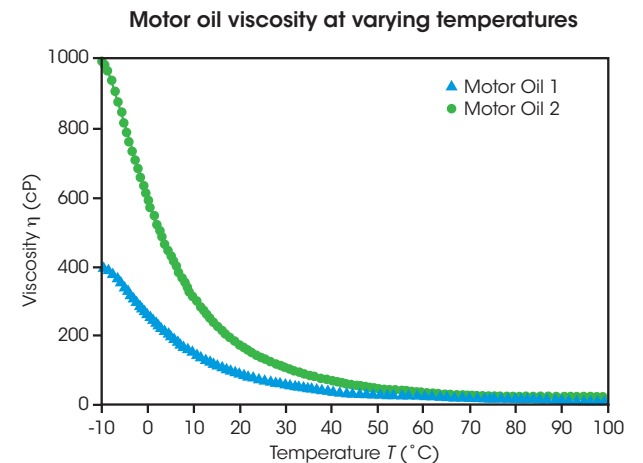
Temperature control is key for accurate rheology data to ensure data reproducibility and evaluate materials' behavior under real-world conditions. The Core Rheometer's integrated Peltier system provides precise, rapid temperature control. Equilibration time is reduced by up to 60% compared to typical viscometer configurations, minimizing down time between different measurements. Built-in air cooling eliminates the need for a liquid circulator, reducing cost, simplifying operation, and saving valuable bench space.



Configuration	
Peltier Plate	-10 °C to 200 °C
Peltier Concentric Cylinder	0 °C to 150 °C

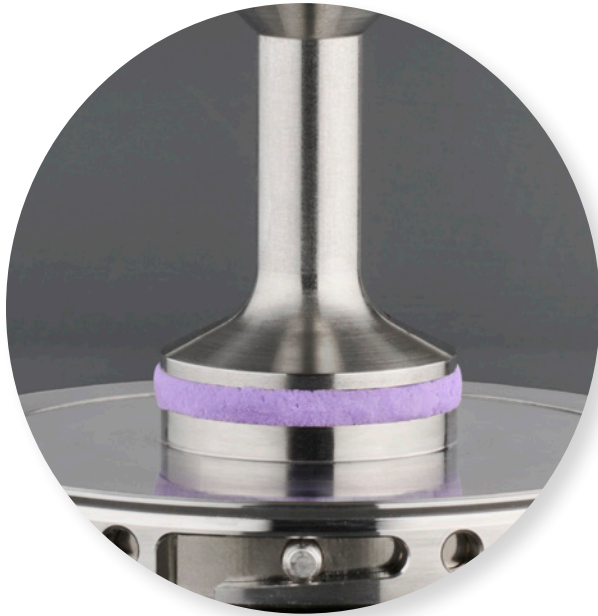


A silicone oil certified reference material measured at 25 °C and 50 °C, using the Insulated Solvent Trap, shows viscosity results within 5% of the reference values (dotted lines), verifying the accuracy of sample temperature



The two motor oils above show low viscosity at the elevated temperature of an active engine. However, their increased viscosity at low temperature is a key consideration when developing products for use in winter conditions

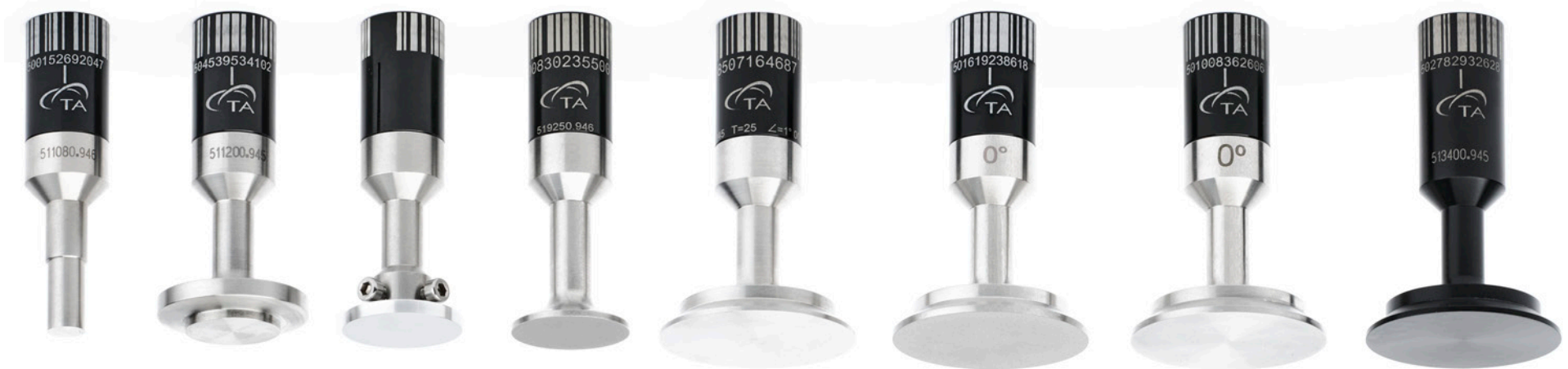
DISCOVERY CORE RHEOMETER | PELTIER PLATE GEOMETRIES



Parallel plate geometries offer versatility for wide ranging materials such as liquids, dispersions, creams and emulsions, gels and pastes, available in sandblasted or crosshatched surface finishes to prevent slip. **Cone** geometries provide a uniform shear rate, ideal for unfilled liquids. Both plate and cone geometries provide the convenience of small sample volumes (<2 mL) and easy cleaning.



SmartSwap2 geometries: Cones and parallel plates, available in a range of dimensions, materials, and surfaces to meet every need



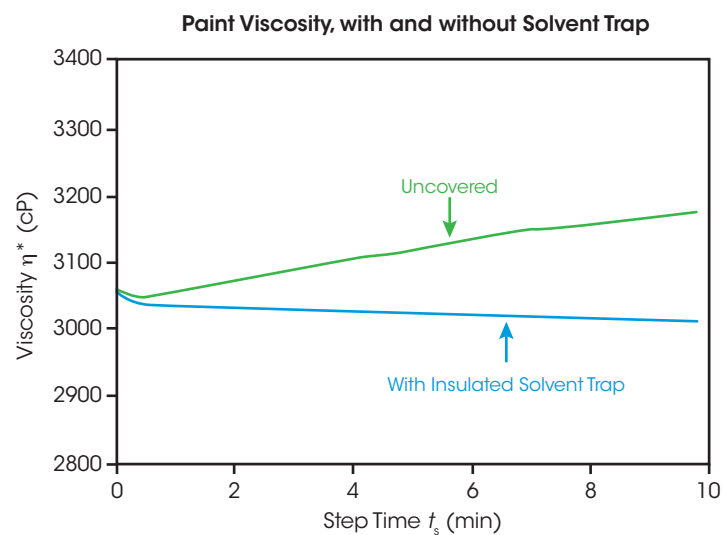
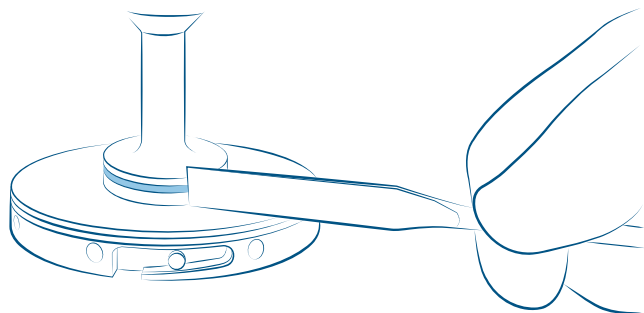
DISCOVERY CORE RHEOMETER | PELTIER PLATE FEATURES



Add an **Insulated Solvent Trap** to prevent drying during measurements. The two split-covers integrate with compatible geometries to create an evaporation barrier. The conductive interior and insulating exterior promote temperature uniformity at extended temperatures.

Below, an acrylic paint's viscosity at 10 sec⁻¹ is measured both with and without a solvent trap cover. Uncovered, paint drying at the edge increases torque and presents as an increase in viscosity. With the solvent trap in place, drying effects are eliminated, and paint viscosity is measured accurately.

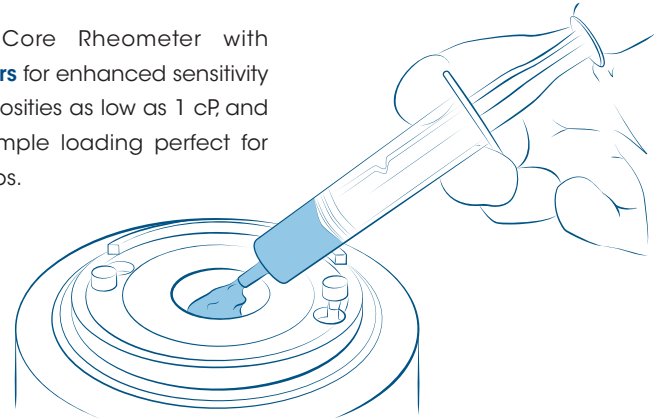
Quick-Change Plates make sample loading easy with a raised step for simplified sample trimming, critical for accurate data. Quick-Change plates match the upper geometry's size and surface finish, and mount directly to the Peltier with a unique tool-free and self-aligning system, swapped in seconds to support multiple sample types.





DISCOVERY CORE RHEOMETER | CONCENTRIC CYLINDER GEOMETRIES

Configure your Core Rheometer with **concentric cylinders** for enhanced sensitivity to characterize viscosities as low as 1 cP, and easy fool-proof sample loading perfect for high-throughput labs.



A variety of upper rotors and lower cups are available to accommodate materials and testing needs, including disposable cups for high-throughput testing.



DESIGNED to STREAMLINE EVERY STEP

- 1 Automatic gap control** provides faster workflow and precise gap positioning. The axial motor automatically raises and lowers the head throughout the method and controls the test gap position with 0.1 μm resolution for accurate and reproducible results.
- 2 Touchscreen** capabilities go beyond basic controls, providing a new user experience ideal for high-throughput labs. Perform routine measurements directly at the instrument without need for PC interaction.
- 3 Integrated lighting** enhances visibility for easier, more reproducible sample preparation leading to increased data accuracy and precision. The sample is automatically spotlighted during user interaction, guiding the operator and signaling test status.
- 4 Smart Swap™ 2** reader automatically identifies attached geometry, recalls dimensions and stored calibrations, and validates geometry aligns with the selected RheoGuide™ method. Smart Swap eliminates common sources of error and enables more efficient operation.
- 5 Compact design** incorporates electronics, Peltier and air-cooling heat exchanger in one unit. Compared to modular systems with liquid circulators, the Core Rheometer requires up to 75% less bench space.



EMPOWER your LAB with RHEOGUIDE™ SOFTWARE

RheoGuide is your entry point to the world of rheology, directly from the Core Rheometer touchscreen. Select a method from the app-style interface and follow instructions and illustrations through every step, eliminating sources of operator error. Results are immediately available on the touchscreen, allowing users to take immediate action, perfect for fast-paced environments.



Rheology testing improves quality and consistency by identifying variations not detected by viscometers, preventing future problems and downstream costs. These insights used in R&D are now available to QA/QC labs, with the ease of use of a viscometer.

Methods are customizable to incorporate every step of your standard operating procedure and instantly indicate Pass or Fail based on your specifications. Test methods are easily synchronized across labs worldwide with consistent operation and data you can trust to drive decisions and solutions.

DISCOVERY CORE RHEOMETER | RHEOGUIDE™ FEATURES AND BENEFITS



Walk up usability: Perform routine tests directly from the instrument touchscreen, from start to finish, without need to interact with the PC.



Guided operation: Pre-defined Methods and on-screen instructions and illustrations direct operator actions in a step-by-step workflow enabling every user to perform successful rheology measurements with minimal training.



Validation throughout: Common sources of error are eliminated- the correct geometry is installed and calibrated, the sample information is updated, and every step is complete. When operators never miss a step, data is more accurate.



Ensure operator safety: On-screen messages alert if the method exceeds safe-touch temperature with reminders for proper PPE. RheoGuide prompts operator interactions when needed and disables interaction when the head is in motion.



Rapid results: Automated analysis results are displayed on the touchscreen immediately upon test completion, along with pass or fail indication. Eliminating the need for routine manual data processing is ideal for fast-paced Quality Assurance/Quality Control testing labs.



Synchronize methods: Discovery Hybrid Rheometer methods directly transfer to Core Rheometers to replicate R&D's measurements in QC testing. Methods shared across instruments and sites help ensure every operator performs the same measurement.



Powered by TRIOS™ software: Customize RheoGuide methods and access all raw data files for additional analysis through TRIOS, the popular software platform from TA Instruments.

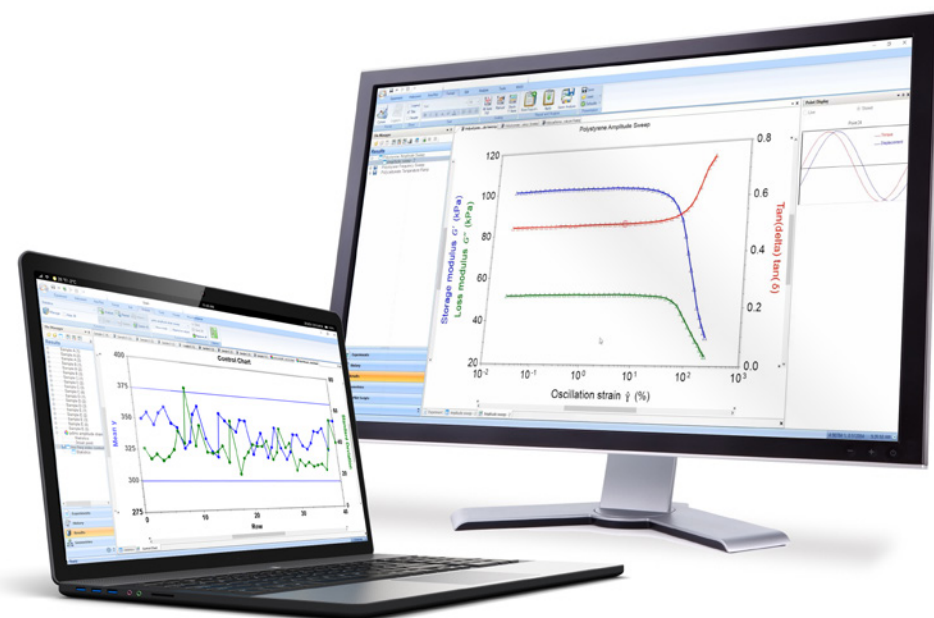
DISCOVERY CORE RHEOMETER | TRIOS SOFTWARE

TRIOS is a state-of-the-art software platform using cutting-edge technology for instrument control, data collection and data analysis for both rheology and thermal analysis. Customize RheoGuide methods to incorporate every step of your standard operating procedure using the intuitive Method Builder.

Complete Data Analysis Capabilities

Every measurement made on the Core Rheometer, whether through RheoGuide or directly in TRIOS, generates a unique data file containing all parameters and raw data for complete traceability.

- Intuitive and flexible data visualization
- Extensive analysis capabilities, including mathematical models, curve fitting, statistics
- Batch Processing: Automated analysis and report generation
- Control Charts for monitoring trends in results over time
- Data export in JSON format for integration with LIMS
- Unlimited licenses: access and analyze your data from anywhere



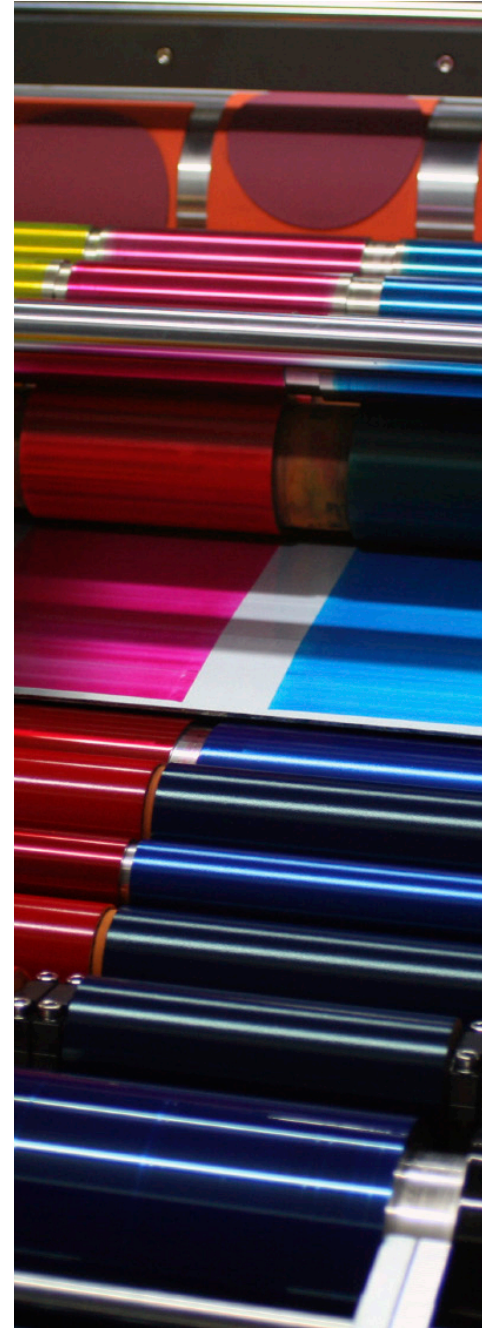
Unlock Direct Rheometer Controls

The Core Rheometer offers more than routine testing – experienced users can switch from RheoGuide mode to TRIOS Classic mode to directly control measurement parameters.

The intuitive user interface allows you to simply and effectively program experiments and move easily between modifying procedures and viewing and analyzing data.



CORE RHEOLOGY | APPLICATIONS



CORE RHEOLOGY | BATTERY SLURRIES

Successful batteries start with the slurry. Whether formulating a new anode or cathode in development, optimizing manufacturing processes during scale-up, or ensuring consistent quality of every batch in production, rheology is a critical component in producing high-performing batteries.

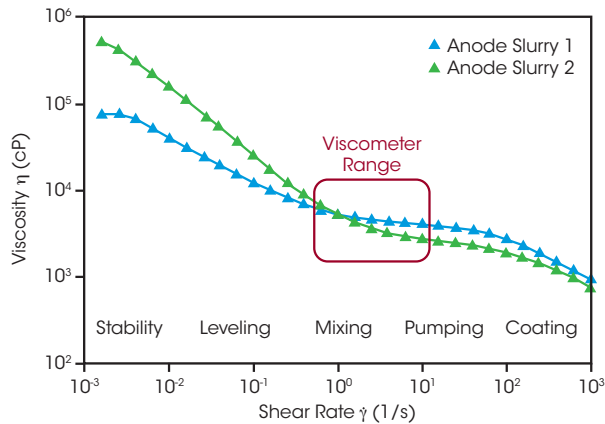
Discovery Core Rheometer Benefits:

- Measure viscosity under process-relevant conditions: coating, mixing, leveling, storage
- Robust stainless-steel geometries suitable for NMP-based slurries
- Concentric cylinder configuration for easy loading of low viscosity slurries, available with disposable cups for high throughput
- Streamlined, guided operation with rapid analysis results to keep up with fast-paced production needs
- Air-cooled Peltier temperature control eliminates the need for a fluid circulator, ideal for operation in a dry room



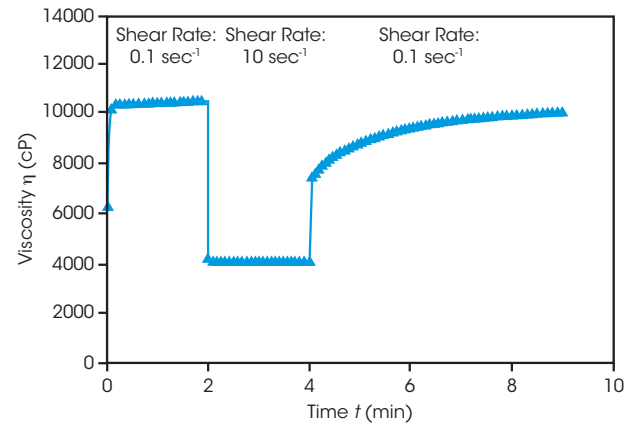
CORE RHEOLOGY | BATTERY SLURRIES

Comprehensive Slurry Flowability



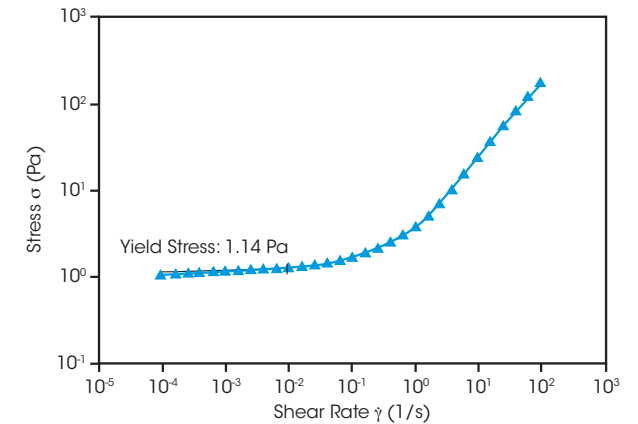
Slurry formulations can be optimized effectively when researchers are able to predict and measure their flow behavior across relevant conditions, ranging from the high shear rates used during the coating process to the very low shear rates experienced at rest. Comparing two experimental anode formulations using only a viscometer suggests their flow behavior is equivalent, but the Core Rheometer's extended range of measurement shows Anode Slurry 2 is more shear thinning, and its higher viscosity at low shear is advantageous to stabilize the dispersion against settling, indicating the active materials are uniformly distributed.

Slurry Recovery After Coating



Ensuring successful electrode production requires understanding of the behavior before, during, and after coating. Initial viscosity at low shear rate (0.1 sec⁻¹) is high, then when shear rate is increased to 10 sec⁻¹ simulating a coating process, viscosity decreases immediately. Reducing the shear rate shows the viscosity gradually rebuilding over time. Rapid recovery often leads to uneven, non-level surfaces. If recovery is too slow, the slurry will continue to spread, causing inconsistent thickness. Both behaviors compromise the efficacy of the resulting electrode.

Yield Stress – Dispersion Stability



Battery materials scientists face a fundamental challenge when developing anode or cathode slurries: maintaining a uniform distribution of the dense solid particles making up the active and conductive materials. Suspension stability is dependent on the slurry's yield stress, the resistance to flow when the material is at rest. Multiple rheological techniques may be used to quantify yield stress, such as the example shown above in which shear rate is decreased until the shear stress reaches a plateau. The Core Rheometer's torque sensitivity enables precise measurements of the internal microstructure impacting a slurry's stability.



CORE RHEOLOGY | PHARMACEUTICALS

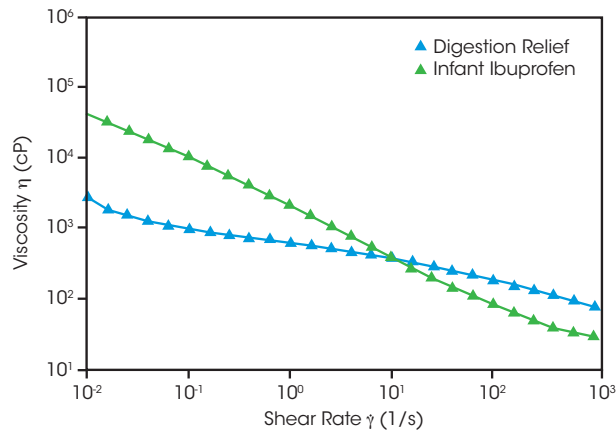
Rheological measurements are key to developing pharmaceuticals with effective drug delivery systems. The Core Rheometer provides the measurements required by pharmaceutical regulatory agencies to ensure API distribution for uniform dosing, enable oral, injectable or topical administration, demonstrate generic equivalence and ensure consistent quality in production.

Discovery Core Rheometer Benefits:

- Versatility to characterize wide range of drug delivery systems: oral, injectable, topical
- Torque sensitivity to measure low viscosity formulations
- Perform required measurements of viscosity, viscoelasticity, yield stress and creep-recovery
- Accurately measure semi-solid topicals with textured surface plates to prevent slip

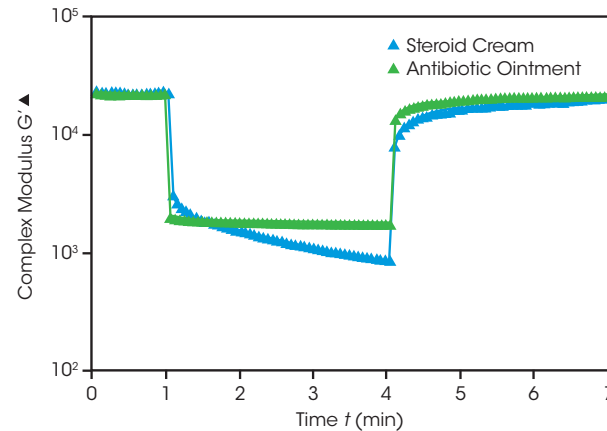


Oral Suspensions



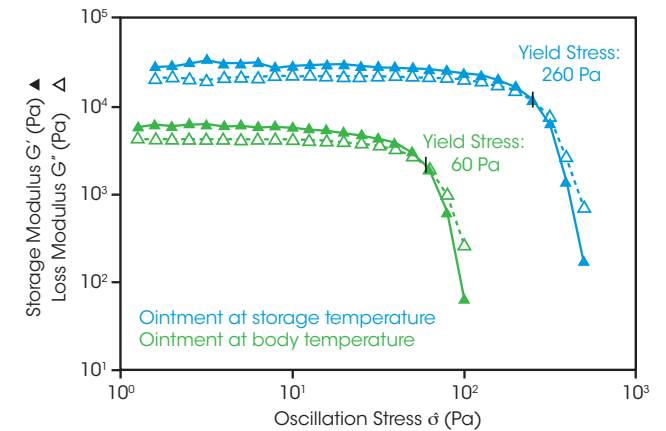
Oral formulations may appear to be simple fluids, but their non-Newtonian flow behavior is vital to their efficacy. Both drug suspensions above show higher viscosity at low shear rates, maintaining drug distribution for consistent API concentration. The infant ibuprofen's shear thinning behavior helps prevent drips during dispensing. Parents can easily administer the medication to a sick infant with accurately controlled dosing.

Topical Emulsion Structure



Topical Ointments must balance stability of dispersion with ease of application. Rheology measures how the emulsion structure breaks down and rebuilds over time. The steroid cream and antibiotic ointment show the same modulus at rest, and both decrease under high deformation, with the steroid cream decreasing over time. At rest, antibiotic ointment rapidly rebuilds while steroid cream shows greater time dependence in its recovery.

Yield Stress vs. Temperature



Topical ointments' yield stress impacts their formulation stability, dispensing from packaging, and behavior after application to the skin. To understand the full range of behavior, yield stress of an ointment is measured at 25 °C (storage temperature) representing the resistance to dispensing, and at 37 °C (body temperature), showing sufficient yield stress is maintained to keep the ointment in place.



CORE RHEOLOGY | PERSONAL CARE

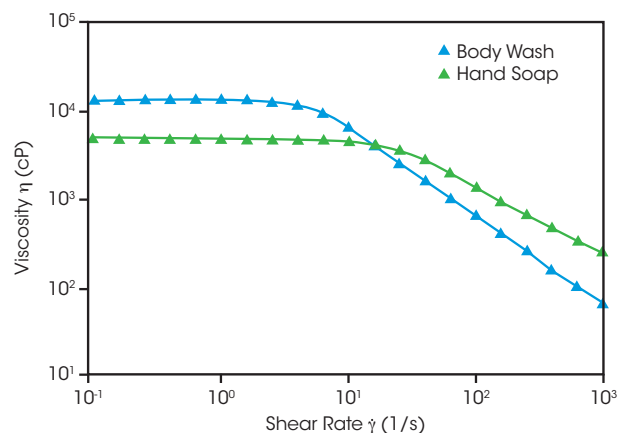
In the competitive personal care and cosmetic industry, consumer perception is a key determinant of product success. Rheology provides a quantitative framework to connect formulation changes with consumer sensory perception and behavior in storage and dispensing, expediting product development. In production, measurements of every batch help ensure customers receive a consistent product

Discovery Core Rheometer Benefits:

- Measure real-world flow behavior impacting application, dispensing and stability
- Streamline routine testing with simplified, guided operation
- Accurately measure creams, gels and soft solids with textured plates preventing slip error
- Characterize a wide range of materials, from low-viscosity serums to soft-solid lipsticks

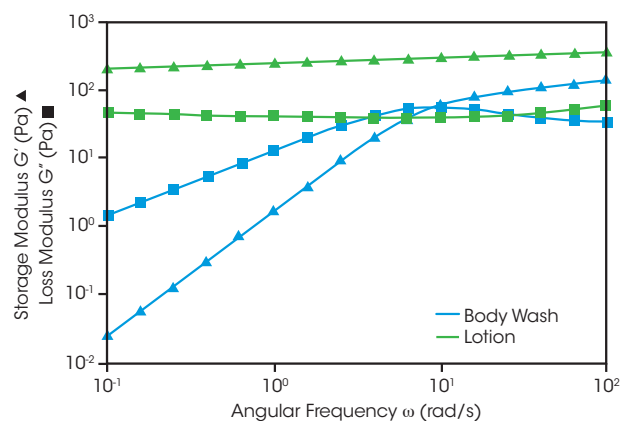


Optimized Flow Behavior



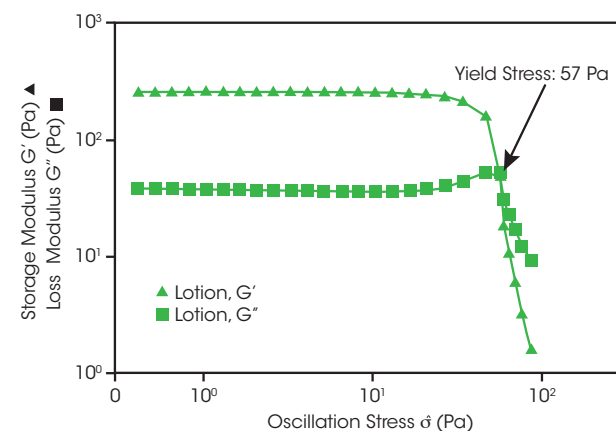
The liquid soaps above show similar viscosities at a medium shear rate but expanding the measurement range shows key differences. Compared to hand soap, body wash shows higher zero-shear viscosity, flowing more slowly at rest. At high rates, body wash is less viscous, more easily spread. Basic viscometers may not detect these differences, but consumers are highly attuned to flow behavior and instinctively reject a body wash that drips off the washcloth or a hand soap that doesn't coat properly.

Viscoelasticity and Emulsion Structure



While viscosity measurements describe flow behavior, oscillatory measurements dive deeper into the underlying microstructure. Frequency Sweep measurements show body wash to be a viscoelastic liquid which flows after a short time as indicated by the frequency of the crossover of Storage Modulus G' and Loss Modulus G'' . Lotion shows Storage Modulus dominating across frequency, indicating an elastic structure that maintains emulsion stability over time.

Yield Stress and Dispensing



Oscillatory measurements of lotion in the linear viscoelastic region show elastic behavior reflecting the emulsion stability, but this structure must be readily deformed in order to dispense and apply to the skin. Increasing the applied oscillatory stress shows the Storage Modulus break down and drop below Loss Modulus, transitioning for solid-like to liquid like behavior. The stress required for this change represents a yield stress, which should be optimized to ensure successful dispensing from packaging.



CORE RHEOLOGY | INKS, PAINTS & COATINGS

Paints, inks and coatings depend on rheology to ensure they flow readily during application, stop flowing to ensure ink print quality and avoid drips in coated surfaces, and achieve level surfaces free of defects. Rheology is fundamental to formulating high-performance products and ensuring consistent quality.

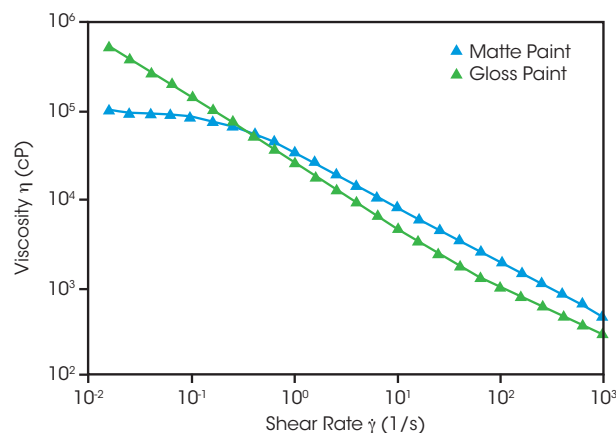
Discovery Core Rheometer Benefits:

- Measure flow behavior under real world conditions related to printing, brushing, coating
- Streamline rheological measurements with guided operation and rapid analysis results to keep up with fast-paced production needs
- Configure with concentric cylinder to avoid drying effects and accurately measure solvent or water-based paints and coatings



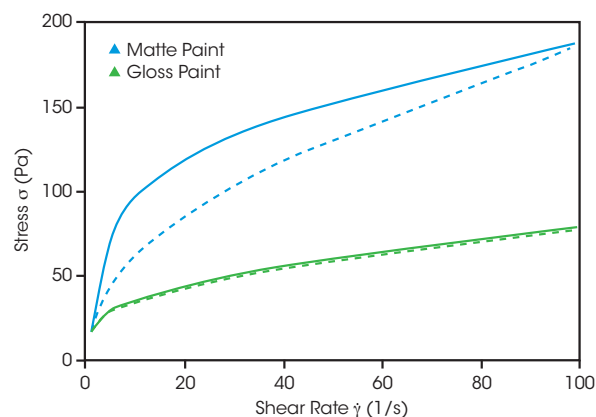
CORE RHEOLOGY | INKS, PAINTS & COATINGS

Formulated for Peak Performance



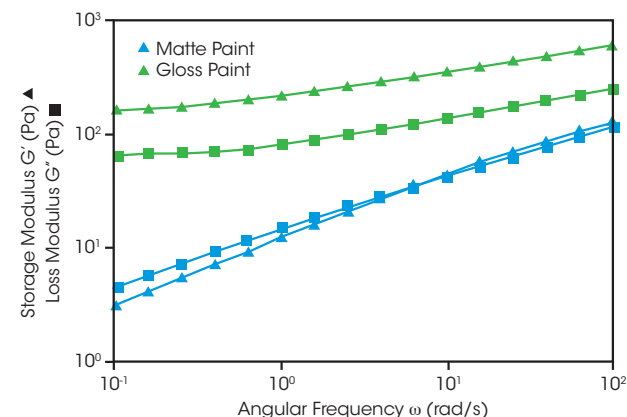
Matte paint is recommended for walls and ceilings, while gloss paint is preferred for doors or molding. But their differences go beyond the surface finish; their rheological behavior is optimized for their target use. At shear rates used in painting, matte paint's higher viscosity helps prevent drips when painting a ceiling, while gloss paint's lower viscosity helps uniformly coat complex shapes in doors and molding.

Sag and Leveling

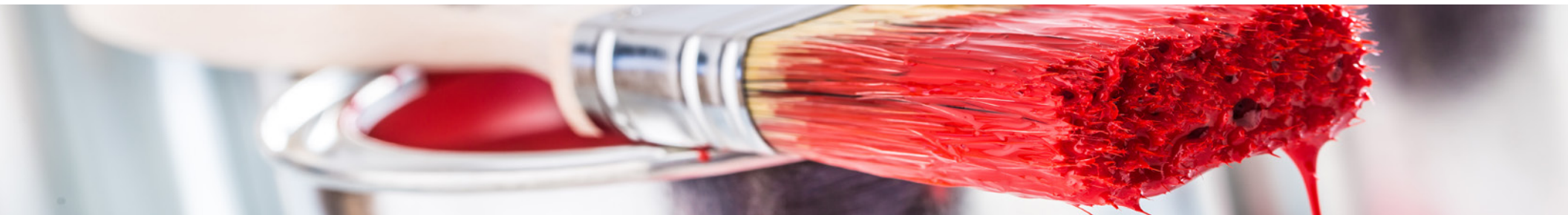


The matte paint shows a significant time-dependent change in viscosity, known as thixotropy. The shear rate is quickly increased from 0 to 100 (1/s), then quickly decreased to 0. The hysteresis seen between the two curves reflects delayed viscosity recovery allowing the paint to spread and produce a uniform, level surface. In contrast, gloss paint shows no thixotropy, indicating instantaneous viscosity recovery.

Viscoelastic Microstructure



Rheology provides insights beyond flow behavior and goes into the microstructure of materials. Oscillatory measurements of these two paints reflect the structure at rest and indicate dramatic differences. Matte paint presents as a typical viscoelastic liquid. Gloss paint shows a gel-like structure due to its polymeric network, which provides high durability and serves to stabilize the dispersion. These viscoelastic measurements provide an indication of structure not available from traditional viscometers.



DISCOVERY CORE RHEOMETER | SPECIFICATIONS

Measurement Specifications	
Minimum Torque (Oscillation)	0.1 μ N.m
Minimum Torque (Steady Shear)	0.3 μ N.m
Maximum Torque	125 mN.m
Torque Resolution	10 nN.m
Displacement Resolution	100 nrad
Maximum Rotational Velocity	300 rad/s
Minimum Angular Frequency	10^{-4} rad/s
Maximum Angular Frequency	628 rad/s
Motor Inertia	< 25 μ N.m.s ²
Gap positioning speed	10 mm/s
Dimensions (width x height x depth)	30 cm x 77 cm x 42 cm 11.8 in x 30.3 in x 16.3 in
Weight	34.5 kg (76 lb)

Peltier Plate Specifications	
Minimum Temperature	-10 °C
Maximum Temperature	200 °C
Temperature Accuracy	0.1 °C
Maximum Heating Rate	50 °C/minute
Maximum Cooling Rate	30 °C/minute
Insulated Solvent Trap	Optional

Features and Technology	
Precision Air Bearings	
SmartSwap™ geometry identification	
Integrated sample spotlight	
Automatic gap positioning	
18 cm touchscreen	
TRIOS™ software	
RheoGuide™ software	

Test Modes	
Flow	Shear rate control
	Stress control
Oscillation	Strain control
	Stress control
Transient	Creep-Recovery
	Stress Relaxation

Concentric Cylinder Specifications	
Minimum Temperature	0 °C
Maximum Temperature	150 °C
Temperature Accuracy	0.1 °C
Maximum Heating Rate	5 °C/minute
Maximum Cooling Rate	5 °C/minute
Disposable Cups	Optional



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