Interfacial Accessory

Rheometers are typically used for measuring bulk or three-dimensional properties of materials. In many materials, such as pharmaceuticals, foods, personal care products and coatings, there is a two-dimensional liquid/liquid or gas/liquid interface with distinct rheological properties. Only TA Instruments offers three separate devices for the most flexible and widest range of quantitative measurements for the study of interfacial rheology. The options include a patented Double Wall Ring (DWR) system for quantitative sub-phase and viscoelastic interfacial measurements, a patented Double Wall Du Noüy Ring (DDR) for samples available in limited volumes, and a traditional Bicone for measurements over the widest measurement ranges. The options include a DWR system for quantitative sub-phase and viscoelastic interfacial measurements. Only TA Instruments offers three separate devices for the most flexible and widest range of quantitative measurements for the study of interfacial rheology. The options include a patented Double Wall Ring (DWR) system for quantitative sub-phase and viscoelastic interfacial measurements, a patented Double Wall Du Noüy Ring (DDR) for samples available in limited volumes, and a traditional Bicone for measurements over the widest measurement ranges.

Interfacial Rheology

Interfacial Geometries

Interfacial rheology geometries provide two-dimensional liquid/liquid or gas/liquid interfaces with distinct rheological properties. The Double Wall Ring (DWR) geometry offers well-defined shear planes on both sides of the geometry surface, permitting the characterization of viscoelastic interfaces. The Double Wall Du Noüy Ring (DDR) geometry provides well-defined shear planes on both sides of the geometry surface, permitting the characterization of viscoelastic interfaces.

Surfactant Concentration & Interfacial Viscosity

Different loadings of surfactant were tested from 0 (just water, no surfactant layer) to 7.2 molecules/nm². Continuous shear experiments were conducted and the interfacial viscosity was measured as a function of surfactant concentration. As expected, the surfactant layer shows significant shear thinning. At high surfactant concentrations, the interfacial shear stress decreases. At high surfactant concentrations, the interfacial shear stress decreases.

Double Wall Ring

The Double Wall Ring (DWR) is the most sensitive interfacial rheology geometry and is capable of truly measuring quantitative viscoelastic parameters. This patented ultra-low inertia ring features a diamond-shaped cross-section to “pin” the interface to the ring. Together, the large diameter and narrow cross-section minimize subphase drag. The low-inertia design ensures the best oscillation measurements over the widest frequency range of any interfacial system. As a result, surface viscosity measurements as low as 10⁻⁷ Pa.s.m are possible without complicated corrections or mathematical manipulation to account for the torque contributions from the individual phases of the interfacial system.

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Interfacial Shear

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The Interfacial Exchange Cell expands TA Instruments’ patented offerings for interfacial rheology by providing the ability to directly manipulate the composition of the lower liquid layer (subphase) during rheological measurements. This unique capability enables the characterization of the interfacial response to a modified subphase composition, opening possibilities for quantifying the effects of changes in pH, salt, or drug concentration, or the introduction of new proteins, surfactants, or other active ingredients.

Controlled Infusion of Soap Solution

The interfacial strength of a protein network adsorbed at an oil/water interface can be affected by factors such as the pH, salt concentration, and presence of surfactants. In this example, a strong and stable network of bovine serum albumin was formed at the interface between a phosphate-buffered saline solution and dodecane. Next, the buffer solution in the subphase was exchanged with a very dilute soap solution. Within minutes after the infusion of the soap solution, the interfacial moduli drop several orders of magnitude, reflecting a dramatic destruction of the protein interface. The introduction of the surfactant lowers the surface tension and displaces protein molecules from the interface. Over time, the continued accumulation of surfactant at the interface brings about the catastrophic destruction of the original protein interface through an orogenic displacement or phase separation processes.

Exchange Cell Trough

The specially designed double wall interfacial trough (2) features strategically placed fluid inlet and outlet ports to exchange the subphase during a rheological measurement. During the experiment, the new subphase is introduced through four ports located at the bottom of the cell while the same volume is simultaneously removed through four ports located just below the fluid/fluid interface. This concurrent exchange and the balanced trough design ensure uniform infusion and withdrawal guaranteeing a constant subphase volume and interface location throughout the test.

Technology

The Interfacial Exchange Cell consists of three key components - the Double Wall Ring geometry, an exchange cell trough with inlet and outlet ports, and a computer-controlled syringe pump. The cell design, based on computational fluid dynamic simulations by Schroyen et al. (1), is optimized to minimize compositional uniformity while maintaining a constant interfacial height and minimize the stress at the interface from pumping fluid into the cell.

Double Wall Ring

The Interfacial Exchange Cell uses the ultra-low inertia Double Wall Ring (DWR) as the measuring geometry featuring a large diameter and a diamond shaped cross-section to ‘pin’ the interface to the ring, the DWR is the preferred platform for sensitive, quantitative interfacial rheology data.

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Syringe Pump

The subphase exchange is precisely executed by a simultaneous infuse/withdraw syringe pump that is directly controlled and programmed through TRIOS software. A pair of syringes at each side allow for a complete and uniform exchange of the subphase volume while maintaining a constant interfacial height. At a representative 6 mL/min flow rate, the subphase volume inside the cell can be completely exchanged within 8 minutes.