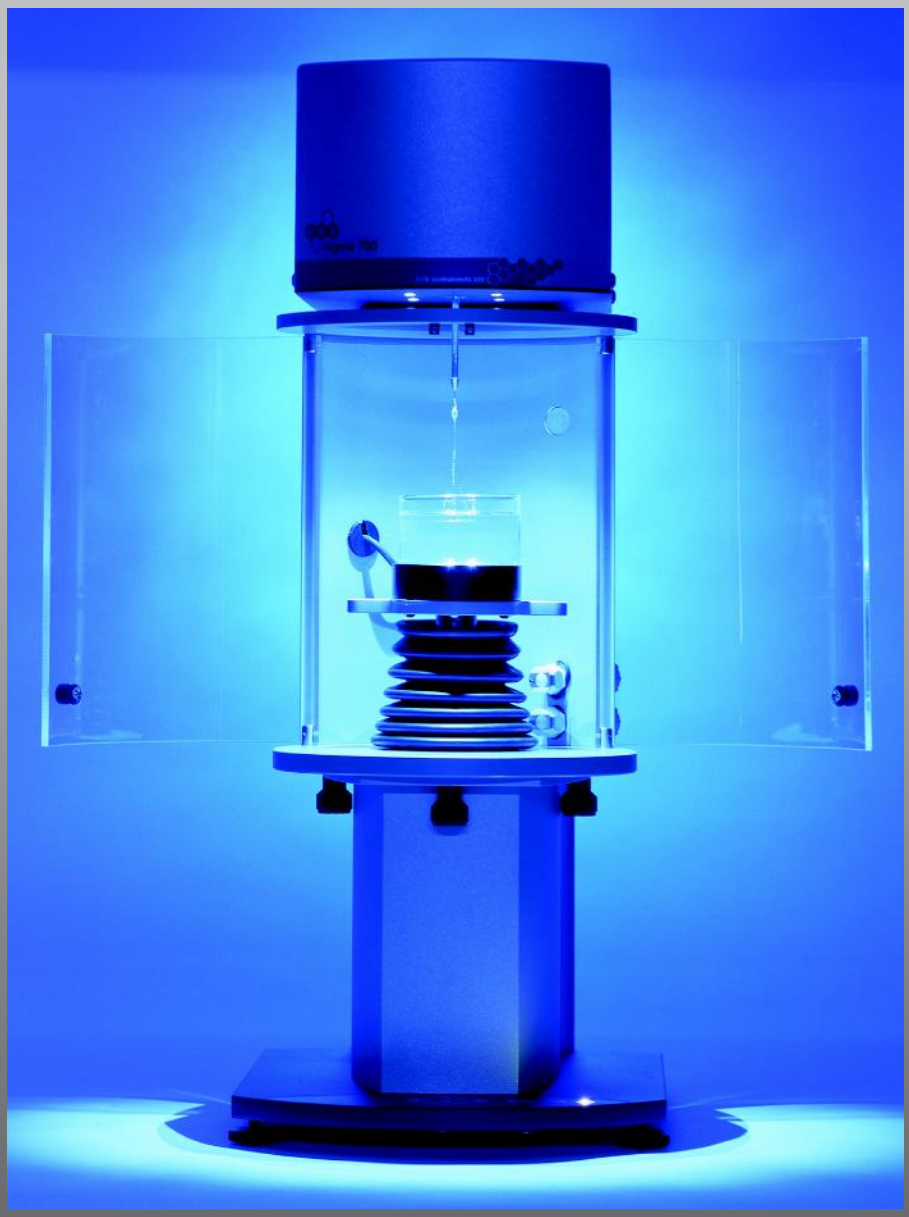
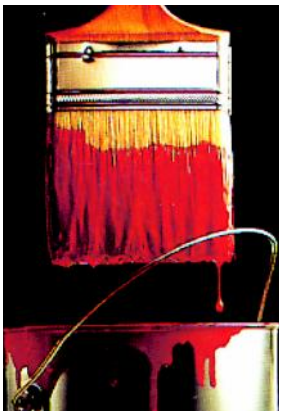
Excellence in Surface Chemistry

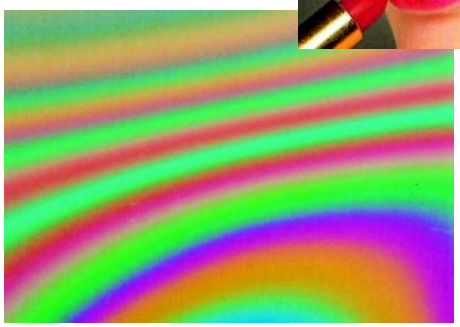
Sigma Tensiometers



Modular Tensiometer System
Sigma 700
Sigma 701
Sigma 702
Sigma 702ET
Sigma 703D

Sigma – Modular Surface Tension/Contact Angle System





From demanding R&D applications to routine measurements, educational teaching and industrial QC use – The Sigma Tensiometers handle them all with ease

Surface Tension (ST), Interfacial Tension (IT), Dynamic Contact Angle (DCA) and Critical Micelle Concentration (CMC) are extremely sensitive indicators when studying surface and interfacial properties of liquids as well as interactions between liquids and solids. Precise characterization of material surfaces and understanding interactions of liquid systems play a vital role in the development of new, better performing products with enhanced qualities. ST, IT, DCA, and CMC provide vital information in the measurement of adhesion, material solubility, biocompatibility, lubricity of solid surfaces as well as wetting, washability, spreading, and adsorption of liquids.

Applications

- Surfactants, Soaps & Detergents
- Emulsions
- Polymers-Plastics
- Pharmaceuticals
- Sprays, Paints & Coatings
- Paper, Film & Ink Products
- Cosmetics
- Textiles
- Food Industry
- Surface Treatments
- Cleanliness
- Transformer Oils

Modularity is the Key

Sigma 700/701/702/703 Tensiometers

The Sigma Tensiometer models are designed to meet the diverse needs of a modern surface chemistry laboratory. Whether your application is in quality assurance at a production line, in educating future surface scientists, or in a demanding R&D project – the Sigma 700 series offer an ideal solution to meet your measurement needs.

Sigma 700
A basic tensiometer for determination of ST, IT, DCA, CMC and other standard measurements by ring or plate methods. Because of its extended weight range microbalance, the Sigma 700 fits a variety of rugged industrial applications and R&D measurements as well as powder testing, density, and wettability.

Sigma 701
A multi-purpose, high-performance tensiometer for applications in industry, R&D and education. Due to its modularity and balance sensitivity it allows for DCA of single fiber and many other high precision measurements.

Sigma 702
A stand-alone tensiometer for measuring surface and interfacial tension in situations requiring high sensitivity and simple operation. The large LCD display and touchpad keyboard enable easy operation without external PC. The option of connecting to an external PC and/or serial printer enables reliable data storage and simple reporting.

Sigma 702ET
A dedicated tensiometer for measuring the interfacial tension of transformer oils according to ASTM D971 and IEC 60422. Sigma 702ET is user friendly and reliable, requiring no previous knowledge of interfacial tension measurement. The step-by-step instructions on the large LCD display ensure fail-safe measurement every time!

Sigma 703D

Sigma 703D
A manually operated computer controlled tensiometer designed for educational, industrial and other multiple user applications. The sigma 703D can measure ST and IT quickly and easily, the results displayed on the large LC-display. The only difference compared with 702 is the manual sample stage. The best choice for occasional tests and QC use.

Stand-alone Sigma 702

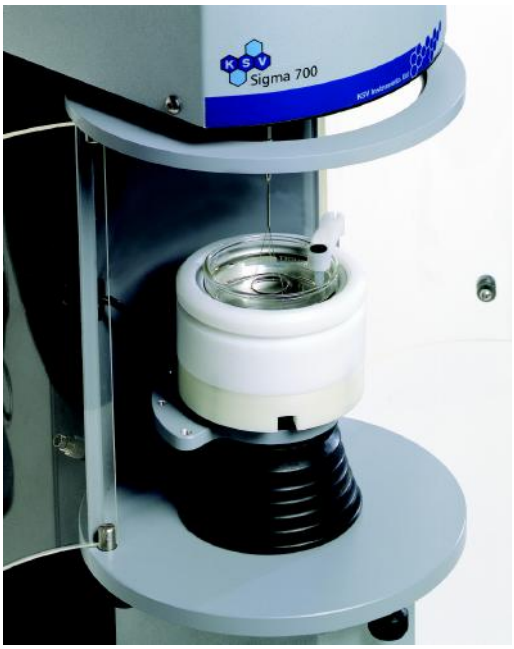
Measuring Unit – Sigma 700/701

Sigma 700/701 Unique Features

- Large working space – wide opening doors
- Dispenser and inert-gas ports
- LED illumination of measuring compartment
- Built in stirrer – no moving parts – no magnetic field during measurement
- Built in connectors for temperature and pH sensors
- Auto-locking & auto-calibrating microbalance (Sigma 700)
- Super-sensitive fiber range balance for standard and single-fiber measurements (Sigma 701)
- Static charge eliminator
- High speed/extended length movement of sample stage
- Large and heavy sample measuring capability
- Thermal separation space between balance and measuring compartment
- Removable measuring compartment for customized future measuring options such as Langmuir studies, high temperature applications, bursting membrane tests and X-Y sample positioning
- Enlarged pull-down sub-window for on-line viewing of selected data
- Optional synchronized dual dispenser software for dilution CMC measurements of highly concentrated solutions

Touchpad for manual system operations without PC control. On-off status light, up-down stage movement button, stirrer and measuring chamber light buttons. Solvent proof design for easy cleaning.

All measuring chamber surfaces are specially coated to resist corrosive liquids and allow easy cleaning. Thermoplastic water jacket for better sample liquid temperature control and elimination of heat loss. Cool surface for worker safety. Rubber bellows for liquid spill protection of the stage shaft and electronics.



Measuring Unit, Modules and Accessories

Modularity makes it possible to tailor the instrument's hardware, software, and performance to meet your exact measurement needs. The Sigma 700/701 design philosophy is straight forward – the desired instrument set-up is built around the Measuring Unit of the Sigma 700/701 by using a variety of software and hardware add-on modules and accessories. The Sigma 700/701 tensiometers are similar and both are compatible with all the system modules and accessories. Only the microbalance and intended use differentiate the Sigma 700 and 701. The Sigma 702 and 703 tensiometers are stand-alone manually operated digital tensiometers and compatible with most of Sigma 700 System accessories.

Sigma 700

The Sigma 700 is a complete, ready to use tensiometer. It uses the latest advances in precision microbalance technology. Special attention is paid to the ergonomic and user-friendly design. The Measuring Unit is the main building block of the system that can be tailored to meet your exact needs.

First determine what needs to be measured and any special conditions that will affect your measurement. Then choose which software modules and accessories are needed to accomplish your task.

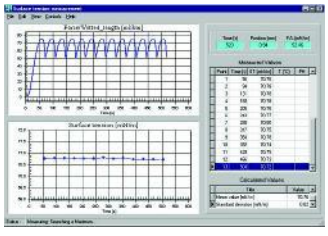
Accessory modules are easily mounted into the Measuring Unit and plug-and-play software modules can be operated by anyone with Windows™ experience. Once the system requirements have been decided, KSV will assemble the Sigma 700 and deliver it in a ready-to-use condition. It possible for the customer to take the instrument directly from its shipping crate and put it to use. Setting up the system, running test experiments, and analysing the data are all covered with step-by-step instructions. The comprehensive operation and installation manual ensures smooth, trouble free set-up of the instrument and software.

Because of its wide weight range and auto-calibrating microbalance, the Sigma 700 is well suited for DCA measurements of large and heavy solid and powder samples. It can run two dispensers simultaneously for CMC measurements. Full PC control over all system functions makes it possible to carry out long measurements without operator intervention during the test – saving time and freeing the operator to concentrate on other tasks.

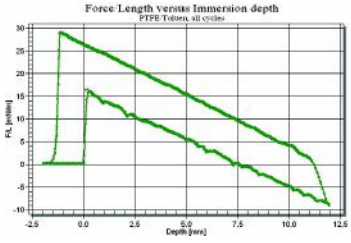
Measuring Unit

Application Specific Software Modules

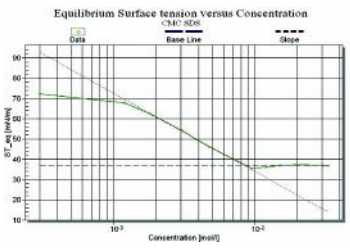
Surface/Interfacial Tension



Dynamic Contact Angle



Critical Micelle Concentration



Adsorption, Powder Wettability

Sigma 701

The Sigma 701 is a multipurpose tensiometer based on the Sigma 700 technology and design but equipped with a different microbalance optimized for a different range of applications. It expands from a basic tensiometer to a fully equipped R&D grade high performance instrument capable of handling most of the known surface chemistry measuring methods. It can run two dispensers simultaneously for CMC measurements and the high resolution balance makes it possible to measure single fibers only a few microns in diameter. The Sigma 701 is an excellent tool for those looking for a high performance, easy to use, standard tensiometer as well as for anyone looking for exacting performance and precision in higher end applications.

Sigma 702 and Sigma 703D

Designed for educational, industrial and routine QC use, the Sigma 702 and 703D take the lead in ease of use and versatility of applications. They offer immediate access to the Surface Tension or Interfacial Tension measurements which are a prerequisite in random fast measurements or when ST/IT needs to be measured occasionally. For further information ask for a separate brochure or go to the KSV web site at www.ksvltd.com.

Sigma 702ET

Sigma 702ET is a dedicated tensiometer for measuring the interfacial tension of transformer oils according to ASTM D971 and IEC 60422.

Sigma 700/701 Performance

- Surface and interfacial tension measurements push and pull modes by ring. Correction calculation by Huh & Mason (Harkins & Jordan, Zuidema & Waters and others supplied.)
- Dynamic advancing and receding contact angle measurements (DCA)
- Contact angle of powders and single fibers
- Automatic critical micelle concentrations (CMC) determination
- Surface energy and adsorption measurement
- Density of liquids and sedimentation

Sigma 700/701 Modules and Accessories

Software Modules

- ST/IT Module – surface/interfacial tension
- DCA Module – dynamic contact angle measurement/single fiber wettability
- CMC Module – for critical micelle concentration
- PW Module - wettability of powders and disperion sedimentation
- DEN Module – liquid density determination

Accessories

- Thermostatic jacket for sample liquid
- Temperature control with temperature probe
- pH probe
- Du Nouy rings – Wilhelmy plates
- Auto dispenser (up to two dispensers)
- Water bath circulators
- Consumables, glassware
- Sample holders – for various types of solid samples
- Density ball
- Certified calibration kit

Sigma 700/701 Features

- Full computer control and automatic operation of all measuring modes
- Wilhelmy plate or Du Nouy ring method
- Ultra-sensitive or extended-range balance, two choices to best suit your application
- Software controlled sample temperature control and stirring – constant or ramp temperature controls
- Direct reading of sample temperature
- Fully automatic dispenser for CMC or dilution measurements
- Automatic calculation of ring correction values
- Informative on-line graphic presentation
- Data export to spreadsheet programs, Excel, Origin, PlotIT etc
- Small sample vessels and measuring probes

PC Software Sigma 700/701

KSV´s Sigma 700/701 is run by a powerful Windows™ software written in C++. The point-and-click format of the software using drop-down menus, buttons, and icons is easily leaned by all users. The software included with the instrument allows the user to perform a variety of pre-programmed experiments which can be modified to particular needs. A wide range of data points and measurement parameters are stored in a database and can easily be retrieved and analyzed later or alternatively exported to another data reduction software.

Standard program include:

- Surface and Interfacial tension
- Dynamic Advancing and Receding Contact Angles (DCA)
- Powder Wettability (contact angle of powders)
- Single Fiber Wettability
- Critical Micelle Concentration (CMC)
- Adsorption Behavior of Solids
- Surface Free Energy of Solids (Fowkes, Wu, Acid-Base)
- Critical Surface Tension (Zisman)
- Wetted Length of Solids
- Density of Liquids

The major parts of the program are the **Main Menu**, **Experimental Setup**, **Experiments** of the software is the **Main Menu** from which all other sections and programs can be accessed.

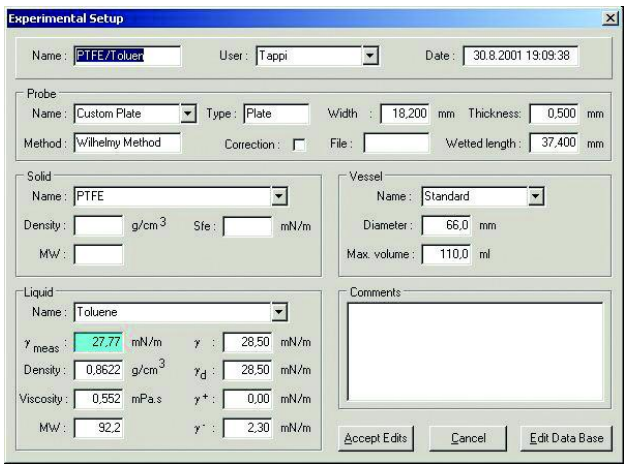
The **Experimental setup** includes information that is specific to each measurement. Once an experiment has been chosen, the various information and parameters are entered in the **Experimental Setup.** This helps to keep the data organized and makes it easier to search for a specific measurement afterwards.

The actual performance of the **Experiments** (Surface/Interfacial Tension, Contact Angle, Critical Micelle Concentration, Absorption, for example) occurs after the **Experimental Setup** has been filled out and the materials for the experiment are in place. Once the final experimental controls have been chosen the experiment is started. The experiment will then continue unsupervised until completion.

After an experiment has been performed you can return to the data for further analysis in the **Data Reduction and Analysis** section. After selecting an experiment the data for that experiment will be displayed. There is an option of viewing and editing the **Experimental setup** which can be very helpful if the data produced should be recalculated based on new information about the materials involved. A variety of graphs for your data can be displayed and printed. Calculation of additional results and export of data can be done.

Main Menu

Experimental setup



Surface and interfacial tension measurements

Du Nouy ring method

This method measures the maximum weight of the liquid lifted by a ring which is pulled out of a liquid surface or interface. The force (F) required to lift the ring is related to the surface tension (s) by the expression s = kF. The factor (k) derives from the capillary pressure across the curved surface of the lifted liquid. The factor (k) depends on the geometrical dimensions of the ring and on the contact angle between the ring surface and the liquid. Reliable measurements can generally be made only if the ring is completely wetted by the liquid, i.e. contact angle equals to zero. Precise determination of the maximum force is achieved by repeatedly rising and lowering the ring close to the rupture of liquid lamella hanging from the ring. Just before the rupture the lamella force applied on the ring decreases dramatically. The balance detects this force change and lowers immediately the ring to eliminate lamella rupture.

Measuring Process

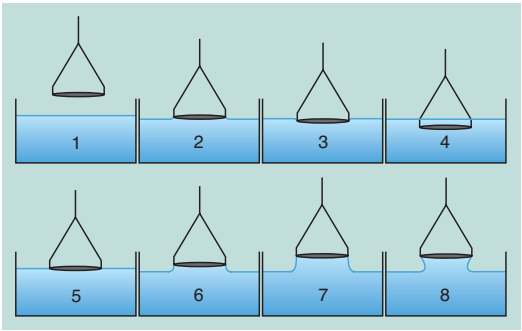
1. The ring is above the surface and the balance is zeroed
2. The ring touches the surface and gets wetted resulting in some positive force
3. Negative force is applied on the ring when it is pushed through the surface into the liquid
4. Some positive force will remain because of the wetting of the vertical supports of the ring
5. When pulled out of the liquid (by lowering the sample cup) the upper surface of the ring touches the liquid surface and the force starts to increase. This is because the surface tension of the liquid tries to prevent the ring from penetrating its surface.
6. The liquid is attached to the ring while pulling it up until the maximum force (7) is reached. At this point the volume of the liquid pulled up by the ring is also at its maximum causing the ring to detach from the liquid.
7. The maximum force needed to pull the ring from the liquid is proportional to the surface tension of the liquid. The greater the force needed the greater is the surface tension.

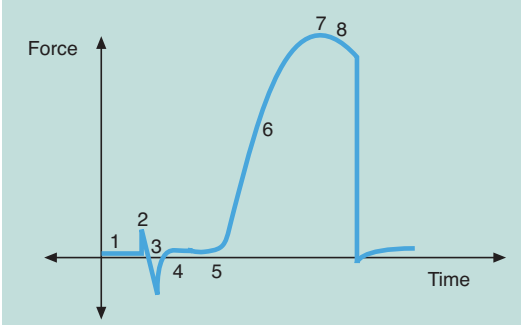
Wilhelmy Plate method

In this method, the weight of the liquid lifted when a plate is withdrawn through the surface is measured. This weight increases to some maximum value which, provided that the plate is completely wetted by the liquid and that the lower edge of the plate is at the same level as the flat surface, equals the surface tension times the length of the contact line between the plate and the liquid. In order to ensure the complete wetting the plate is usually made of micro-roughened platinum.

Static measurement
The sample surface is lifted until it contacts the lower edge of the plate. The wetting or capillary force pulls liquid up on the surface of the plate until equilibrium is reached.

Dynamic measurements
The plate is completely immersed into the liquid and then withdrawn through the surface until the maximum force is reached. In order to achieve a precise determination of the maximum the plate is not detached from the surface but repeatedly lowered and pulled back to the maximum.

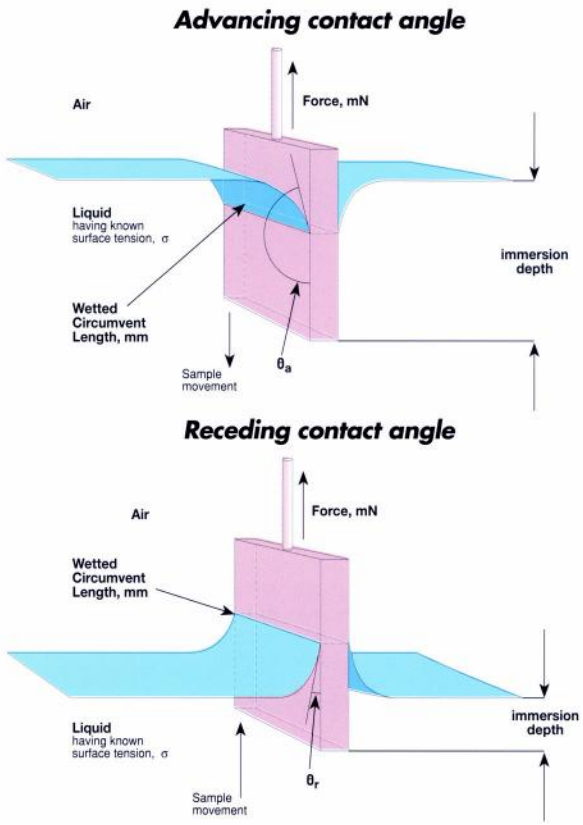




Dynamic Contact Angle measurement

Measurement of dynamic contact angles provides information on the properties of surfaces such as porosity and homogeneity, surface topography and reactivity. The contact angle is the angle between the tangent to the liquid surface and the liquid/solid surface at the point of liquid/solid contact. The method is based on the Wilhelmy plate principle where the solid sample is held by the electro balance and then pushed into or pulled from the substance. Therefore the measured force acting on the sample alternates depending on direction of the movement. The force differences obtained are directly proportional to the differences is contact angle. As the solid sample penetrates into the liquid an advancing contact angle is determined while pulling the sample from the liquid provides receding contact angle information.

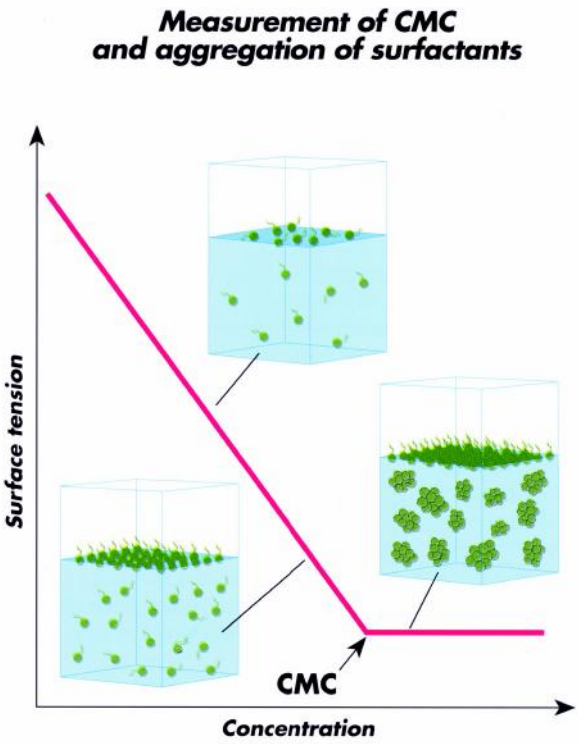
The progress of the experiment is shown graphically with the x-axis representing the immersion depth and the y-axis the force. The contact angles are calculated from the force versus depth information.



CMC measurement

The structure of surfactant molecules can be clearly divided into polar and non-polar parts. As a result, dissolved surfactants tend to concentrate at the solution surface so that the part of the molecule least compatible with the solvent orients itself away from the solution.

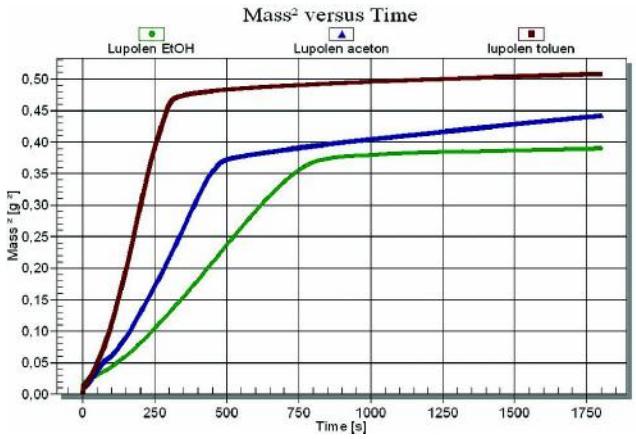
Even at quite low total concentrations the surfactants form a fairly densely packed monolayer at the surface. This results in a rapidly decreasing surface tension. Above a certain concentration, called the critical micelle concentration, CMC, the surfactant molecules form large aggregates, micelles, in the solution. Above the CMC the surface tension is almost independent of the bulk concentration because virtually all additional surfactant forms micelles. Hence, the value of the CMC, which is characteristic for a given surfactant, can be determined by measurement of surface tension as a function of concentration. The Sigma software totally automates the CMC measurements.



Software

Powder wettability measurement

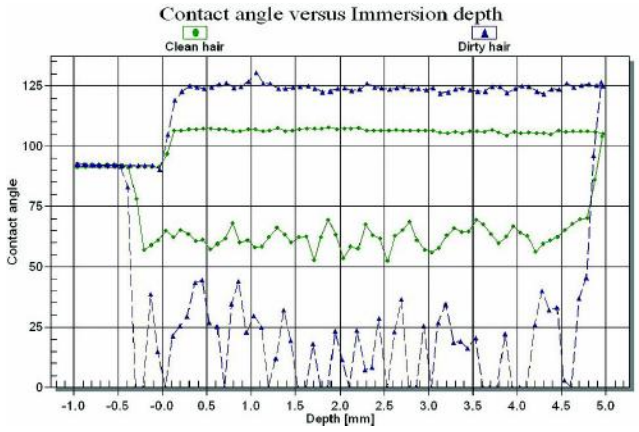
Wettability of powders e.g., determination of contact angles and surface free energies of powders is performed according to the Washburn method. The powder is packed in a glass vessel with a fine sinter glass porous bottom, or metal vessel with filter paper in the bottom allowing liquid penetration but preventing the powder to fall through. As soon as the bottom touches the liquid surface the liquid penetrates and absorbs into the powder resulting in wetting of the powder. Change of weight as function of time is measured.



Test report sheet for three different powders.

Single fiber contact angle measurement

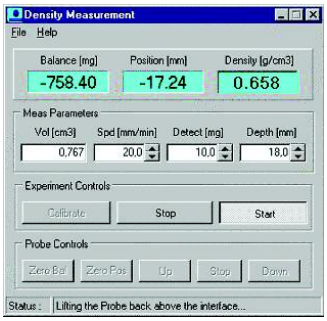
Because of the super-sensitive balance of the Sigma 701 the dynamic contact angle of single fibers or fiber bundles can be measured.



Test report sheet for DCA of clean and dirty hair.

Density measurement

Liquid density is measured with a density kit. A glass density probe with known volume is hung from the balance hook and immersed into the liquid to be measured. The force needed to hold the probe at a constant depth in the liquid is then recorded. The software automatically calculates the density of the liquid using the principle of Archimedes.



Screen showing density measuring result.

Compliance to Standards and Norms

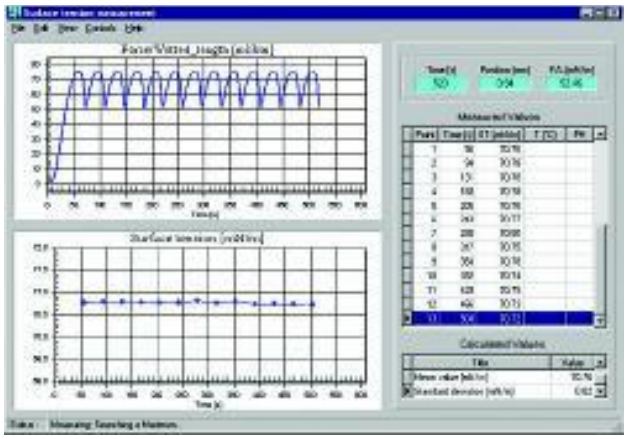
The Sigma 700 covers most of the known force balance methods in today's modern surface chemistry laboratory while meeting the international standards set by ISO and ASTM.

ISO 6889	IT – oil/water
ISO 6295	IT of liquid films
ISO 1409	ST by ring for polymers and plastics
ISO 304	ST of surface active films by drawing up liquid films
ISO 4311	CMC of anionic and non-ionic surface active agents by plate, stirrup or ring
DIN 53914	Du Nouy ring
DIN 53993	Interfacial tension
ASTM D 1590	ST of water
ASTM D 1417	ST of synthetic rubber latices
ASTM D 1331	ST/IT of Surface active agent solutions
ASTM D 971	
EN 14370	
JIS K2241	
IEC 60422	IT of oil/ water by Du Nouy ring

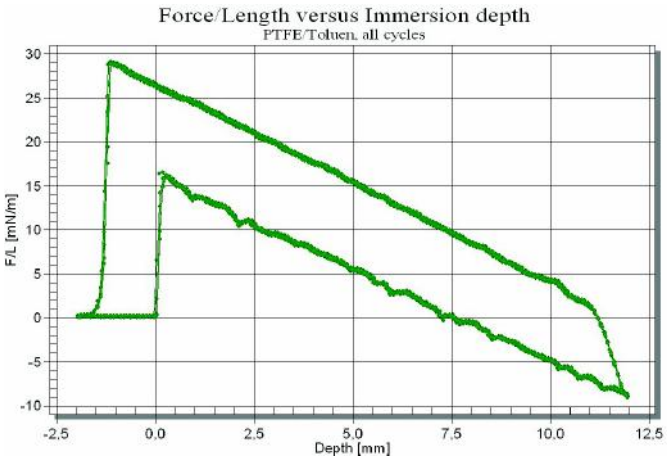
Special application example

Langmuir films – For highly accurate Langmuir film measurements, such as dilational rheological studies, the measuring chamber of the Sigma 700 and 701can be removed, and replaced by a small Langmuir trough – the KSV MiniMicro.

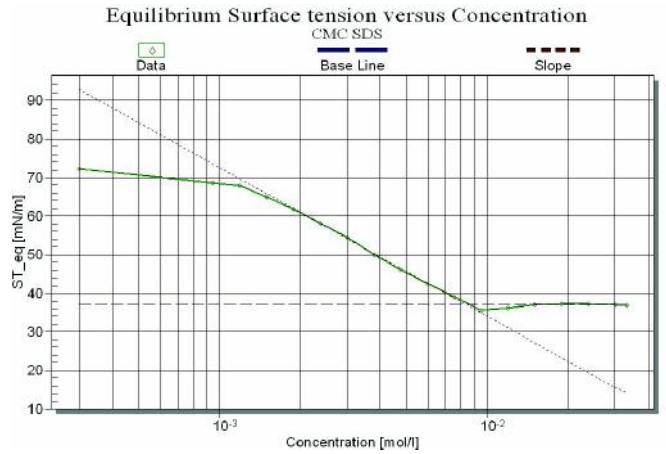
Surface/Interfacial Tension



Dynamic Contact Angle



Critical Micelle Concentration



Sigma Specifications

Balance specifications

Sigma 700 (extended range balance)

Measuring range	1 - 2000 mN/m
Resolution with standard probe	0.001 mN/m
Maximum load	210 g
Weighing resolution	0.01 mg
Force resolution	0.1 µN
Contact angle range	0-180
Contact Angle resolution	0.01°
Automatic calibration and locking	

Sigma 701 (super sensitive balance)

Measuring range	1 - 1000 mN/m
Resolution standard probe	0.001 mN/m
Maximum load (701)	5 g
Weighing resolution	0.005 mg
Force resolution	0.05 µN
Contact angle range	0-180
Contact Angle resolution	0.01°

Sigma 700/701 Measuring Unit specifications

Stage speed (others by request)	0.01 - 500 mm/min
Stage positioning resolution (Step size)	0.015 µm
Computer interface	USB (RS232 as option)

Temperature range

Thermoplastic water jacket	-10 ... 80°C
Stainless steel water jacket	-10 ... 150°C
Electronically heated jacket	room temp. up to 250°C (others by request)
Size	24 x 33 x 62 cm (D x W x H)
Weight	20 kg
Power supply	85-264 VAC
Frequency	47-440 Hz

Sigma Specifications (cont.)

Sigma 702, 702ET and 703D Specifications

Maximum balance load	5 g
Weighing resolution	0.01 mg
Maximum surface/interfacial tension	1000 mN/m
Resolution (display resolution)	0.01 mN/m
Density range	1-2200 kg/m³
Stage speed	0.01 -500 mm/min (Sigma 702 & 702ET only)
Stage position resolution	0.3 µm (Sigma 702 & 702ET only)
Size	24 x 33 x 62 cm (D x W x H)
Weight	20 kg
Power supply	85-264 VAC
Frequency	47-440 Hz

Sigma 700/701 Software Modules

S700	ST/IT software
S701	DCA software
S702	CMC software
S703	Density software
S704	Powder Wettability and Sedimentation Software

Sigma 700/701 accessories

T705	Thermostatic vessel
T706	Magnetic stirrer
T708	Computerized temperature controller
T101	Dispenser for CMC measurements
T102	Bath/circulator PC operated
T102USB	RS232/USB adapter
T103	Bath/circulator manually controlled
T104	Sample Vessel 70 mm
T105	Sample Vessel 50 mm
T106	Du Nouy ring Pt-Ir-ring
T106B	Calibration Certificate for Du Nouy ring
T107	Wilhelmy Plate Pt
T107A	Certificate for Wilhelmy plate dimensions
T107B	Platinum Rod
T108	Ring re-form tool
T108A	Ring re-form service
T109RF	Sample holder for rigid and flexible plates
T111	Sample holder for fibers
T112	Powder wettability measuring device
T113	Density kit
T115	Gas phase temperature controller
T117	Certified Calibration Weight
T117A	Calibration Certificate for Du Nouy ring
T117B	Certified calibration kit
T118	pH meter
T119	Sedimentation kit
T130	Computer with software installed

The Company

KSV Instruments Ltd is a leading global provider of routine, research and characterization instruments for surface chemistry and Langmuir-Blodgett film applications. Our headquarters are in Helsinki, Finland and we have offices in North America and Sweden and trained representatives throughout the world.

Interfacial Characterization

With Sigma tensiometers and CAM Drop Shape Analysis contact angle meters and their various modifications KSV covers most of the known interfacial measurement techniques. All instruments utilize the latest technological advances in measurement of surface/ interfacial tension of liquids as well as contact angles and surface free energies.

Langmuir Film Preparation and Characterization

Ranging from manual, educational instruments to fully equipped high performance R&D grade multi/alternating layer LB-troughs KSV offers the widest range of Langmuir systems in the world. KSV's BAM (Brewster Angle Microscope) and ISR (Interfacial Shear Rheometer) are used for characterization of Langmuir and LB films in a wide variety of nanotechnology, biology and molecular engineering applications.

Dip Coating

A wide variety of dip-coaters for exacting applications, from single manual dippers to automatic multiple dipping devices.

Process Control

KSV makes a range of at-line (AL) and on-line (OL) process control tools for monitoring surface tension, temperature, pH, viscosity and conductivity. An option also exists for automatic dosing of surfactants.

KSV Instruments

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