TRACKER™

DROP TENSIOMETERS & INTERFACIAL RHEOMETERS

A Complete Range of Measuring Instruments
For Surface Tension & Interfacial Rheology Study

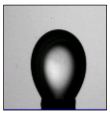
ABOUT SURFACE TENSION & INTERFACIAL RHEOLOGY

Surface tension and interfacial tension play an important role in our everyday life. Numbers of industrial applications are utilizing interfacial tension phenomenon and require to characterize dispersed systems such as foams and emulsions as well as the surface energy of solids.

TRACKER™ automatic drop tensiometers, helps you characterize, easily and precisely, the properties of the interfaces between 2 immiscible fluids. Measurements provide valuable data, saving time and money in formulating products.

Measuring Principle

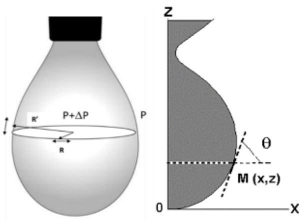
TRACKER™ determines the dynamic interfacial tension between two immiscible fluids by performing a numerical analysis of the shape of a drop or bubble. Two different configurations are possible:



Rising Drop/Bubble: when the density of the fluid inside the drop is lower than the one inside the cuvette.

Pendant Drop/Bubble: when the density of the fluid inside the drop is higher than the one inside the cuvette.

TRACKER™ software uses algorithms to analyze the drop's profile and to fit it with models based on the Young-Laplace equation in order to determine surface tension, interfacial tension or contact angle.



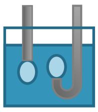
$$\Delta P = \gamma \cdot \left(\frac{1}{R} + \frac{1}{R'} \right)$$

the pressure difference caused by the curvature of the surface is proportional to the average curvature, the proportionality coefficient being precisely the interfacial tension

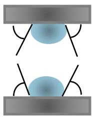
TRACKER™ software controls the variations in volume or area of the drop in both frequency and amplitude. Therefore it makes possible to study the rheological properties of the interfaces.

The automated regulation guarantees precise and reproducible measurements. Up to 60 frames per second can be recorded. The software calculates the measurements in real time.

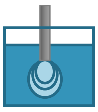
Range of Measurements



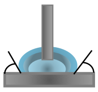
Surface Tension measurement at Liquid/Gas **or interfacial Tension** measurement at Liquid/Liquid interface.



Contact Angle measurement at Liquid/solid interface. The measurement determines the wettability of the solid and the deduction of the surface energy of the solid.



Interfacial Rheology measures the evolution of surface or interfacial tension on a drop / bubble whose volume varies in sinusoidal cycles.



Dynamic Contact Angle : measures the advancing and receding contact angle when the volume of the drop varies.

Data & Measurements

- Tension vs time (accuracy 0,01 mN/m)
- Contact angle
- Temperature: up to 200°C
- Pressure: up to 700bars
- Drop volume / area
- Viscoelastic modulus: Elastic component (real part) & Viscous component (imaginary part)
- Coefficient of rigidity
- Bond number
- Critical Micellar Concentration

Examples of Applications…

Crude oil: emulsion stability for separation, influence of surfactants for oil recovery, dynamic contact angle crude oil/rock/liquid phases.

Cosmetics: emulsion stability, physical-chemical formulation, dynamic contact angle container/emulsion.

Food: Food packaging, stability of emulsion before getting frozen (ice cream), influence of proteins, sugar or alcohol on the bubble size.

Bitumen: wettability, emulsion properties at different temperatures, dynamic contact angle.

Fuel formulation: characterization of the coalescence of an emulsion, wettability.

Lubricant: contact angle (lubricant/material), influence of surfactants on the wettability

A COMPLETE RANGE OF AUTOMATIC DROP TENSIOMETERS

Standard Instruments

designed to characterize Interface properties in most Applications

TRACKER™

- Automatic Drop Tensiometer
- Surface/interfacial tension, contact angle and interfacial rheology measurements
- Pendant or rising drop configuration
- Data calculation in real time
- Temperature up to 90°C

TRACKER™ MODULES / OPTIONS

- Dense phase exchange
- Drop phase exchange
- Automatic CMC
- Piezoelectric cell for high frequency drop oscillation
- Pressure sensor to measure Laplace pressure inside the drop
- Goniometer / automatic drop deposit

High Pressure Instruments

designed to characterize Interface properties in demanding Applications

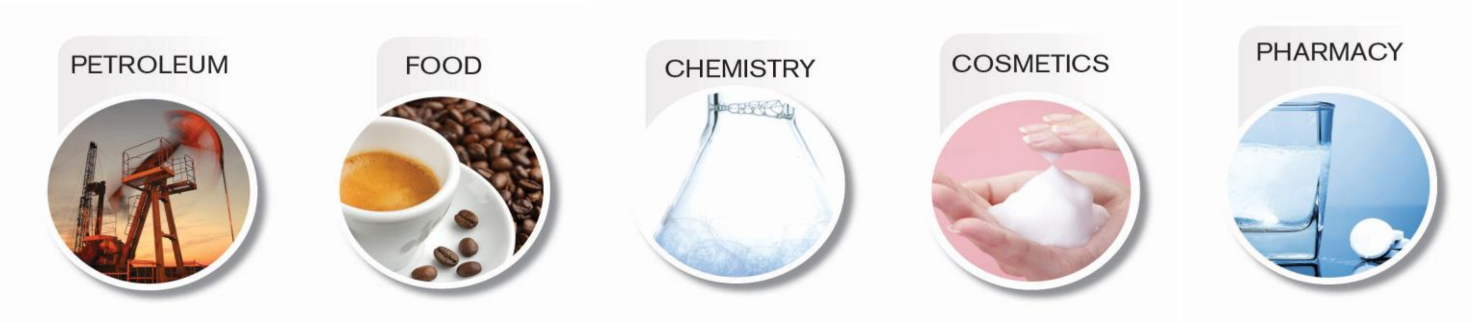
TRACKER™ H - Pressure Cell 200 bar

- Automatic Drop Tensiometer equipped with a removable high pressure and temperature measurement cell
- Surface/interfacial tension, contact angle and interfacial rheology measurements
- Pendant or rising drop configuration
- Data calculation in real time
- pressure up to 200bar
- Temperature up to 200°C

TRACKER™ HTHP - Pressure Cell 700 bar

- Automatic Drop Tensiometer equipped with a very high pressure and temperature measurement cell
- Surface/interfacial tension, contact angle and interfacial rheology measurements
- Pendant or rising drop configuration
- Data calculation in real time
- High pressure up to 700bar
- High temperature up to 200°C

…For many Research Applications



STANDARD TRACKER™

designed to characterize Surface Tension
& Interfacial Rheology in most applications

TRACKER™, automatic single drop Tensiometer, is designed to measure surface / interfacial tension, contact angle, and study interfacial rheology.

Thanks to its smart modular design, TRACKER™ is adaptable to many applications and allows you to choose the instrument that matches your application choosing one or more modules and options:

- Phase exchange
- Piezoelectric cell for higher frequency drop oscillation
- Pressure sensor to measure Laplace pressure
- Automatic CMC module
- Pressure Cell 200°C/200bar

Optical System

TRACKER™ is equipped with a monochrome CCD camera with a resolution of 640x480 pixels and a tele-centric lens. The camera records up to 60 frames per second (fps) covering most applications. When very fast phenomena are studied, a fast camera (up to 600 fps) is provided.

A distortion correction, stored in the software, is used to correct the acquired image for maximum measurement accuracy. Therefore, resolutions lower than pixel (0.2 px) are obtained.

A light source illuminates the sample in a homogeneous and constant manner. The grayscale variation of one pixel only varies by ± 10 grayscales out of 256. The light source has 2 luminous intensities to adapt to solutions with higher optical density.

Measurement device

TRACKER™ is equipped with a cuvette surrounded with a thermostatic envelop. A magnetic stirrer is integrated into the base of the supporting plate to mix samples if solution concentration is changed during experiment.

Temperature can be controlled up to 90°C for both the cuvette and the syringe by using a circulating bath. A temperature-sensing probe is provided to record temperature of the sample or sample jacket (accuracy ± 0.2°C).

Data from the temperature probe are automatically recorded in the software along with sample results. Thus density values can be adjusted with the actual temperature.

TRACKER™ is equipped with a removable platform which allows the horizontality to be adjusted in order to measure the static or dynamic contact angle between a liquid and a solid.

TRACKER™ can be provided in a protective box that prevent from light when operating experiments and protects the instrument from dust.

Data & Measurements

• Surface Tension (liquid/gas)
• Interfacial Tension (liquid/liquid)
• Contact angle & Surface Energy (liquid/solid)
• Advancing and receding Contact angle
• Interfacial rheology – Viscoelastic modulus
   ✓ Surface Elasticity
   ✓ Surface Viscosity
• Coefficient of rigidity
• Critical Micelle Concentration (CMC)
• Temperature

Applications

- Surfactant characterization
- Efficiency/Effectiveness of the surfactants
- Quantity of surfactant to saturate the surface
- Surfactant behavior on the surface
- Wettability of the surface
- Properties of biological surfactants (protein, lipids ...)
- Competition of surfactants…

Software

The interfacial tension can be calculated from the profile of a drop which exhibits a revolution symmetry.

The actual shape of the drop results from the interactions between the interfacial tension and the effects of gravity. The interfacial tension gives the drop a spherical shape, whereas gravity elongates it, so that it becomes pear-shaped, or flattened in the case of a sessile drop. If these antagonistic effects have absolute values of the same order, it is possible to determine the shape of the resulting profile, as well as the contact angles between the drop and its support.

The calculation is based on 2 fundamental equations :

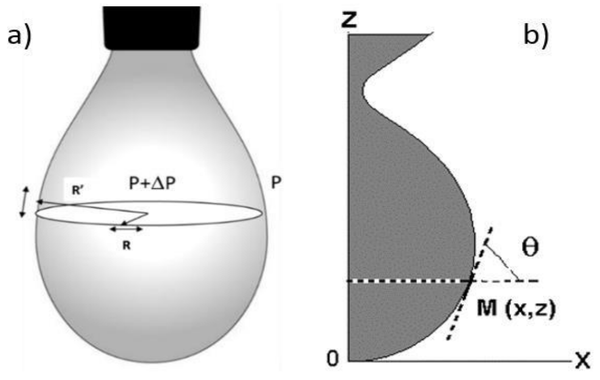


Figure 1.a/Surface curvature of the drop.
b/Coordinates of a point M of the drop surface

- The Laplace-Young equation expresses the fact that the difference in pressure resulting from the surface curvature is proportional to the average curvature, the coefficient of proportionality being equal to the interfacial tension:

$$\Delta P = \gamma \cdot \left(\frac{1}{R} + \frac{1}{R'} \right)$$

R et R' are the main radii
ΔP is the pressure variation across the interface
(Figure 1.a).

- The second equation is based on the equilibrium of the forces across any horizontal plane:

$$2\pi \cdot x \cdot \gamma \cdot \sin\theta = V \cdot (\rho_1 - \rho_2) \cdot g + \pi \cdot x^2 \cdot p$$

p is the pressure exerted on the surface of the drop
γ is the interfacial tension
R et R' are the main drop surface curvature radii
x is the abscissa of the meridian point having z as its ordinate
θ is the polar angle of the tangent to M(s) with axis Ox
V is the volume of the fluid beneath the plane
ρ_1 et ρ_2 are the densities of fluids
g is the acceleration of gravity
(Figure 1.b).

The shape of a drop depends only on the non-dimensioned shape factor named the shape factor or Bond number:

$$Bo = \frac{g\Delta\rho}{\gamma b^2} = \frac{c}{b^2}$$

Δρ is the density difference between the two fluids
g is the acceleration of gravity
b is the inverse of the radius of curvature at the apex
γ is the interfacial tension
c the capillary constant $c = \frac{g\Delta\rho}{\gamma}$

The lower *Bo* is, the more spherical is the drop and the less accurate the measurement (Figure 2-3). To increase *Bo*, it is necessary to increase the radius of curvature at the apex of the drop and thus increase the volume of the drop. The more pear-shaped the drop, the better the measurement.

The value of the Bond number can also be affected by errors due to the optical distortion of the camera lenses and the verticality of the drop.

A good indicator for a precise measurement of the drop's shape is *Bo* higher than 0.1.

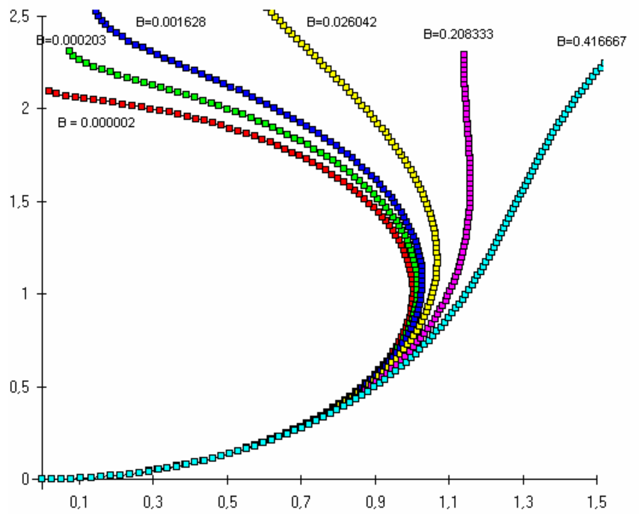


Figure 2 Drop profiles for different Bond numbers

	Bo = 0.1	Bo = 0.01
Gaussian noise (mm)	Relative error	Relative error
0.001	0.25 %	2.3 %
0.005	1.7 %	12.15 %
0.009	2.2 %	28.6 %
0.013	2.7 %	27.6 %
0.017	2.4 %	42.0 %
0.021	5.0 %	53.7 %

Figure 3 Relative error given by the Laplacian profile of the drop according to the Gaussian noise for 2 values of *Bo*

TRACKER™ is automated to perform accurate measurements, produce reliable results and perform reproducible manipulations.

Contact angle measurement allows to determine the wettability of a liquid and the surface energy of a solid. Contact angle measurement can be made on drops deposited manually or automatically driven by the software (option). Contact angle can be calculated from a liquid drop placed on or beneath a solid surface. Measurement begins as soon as the drop detaches from the needle and contacts the solid.

Surface and Interfacial Tension measurements are made with both rising or pendant liquid drops or gas bubbles depending on the density of the fluids.

Measuring over the time (Ex1) makes it possible to determine both the surface tension at equilibrium and the kinetics of adsorption of surfactant molecules.

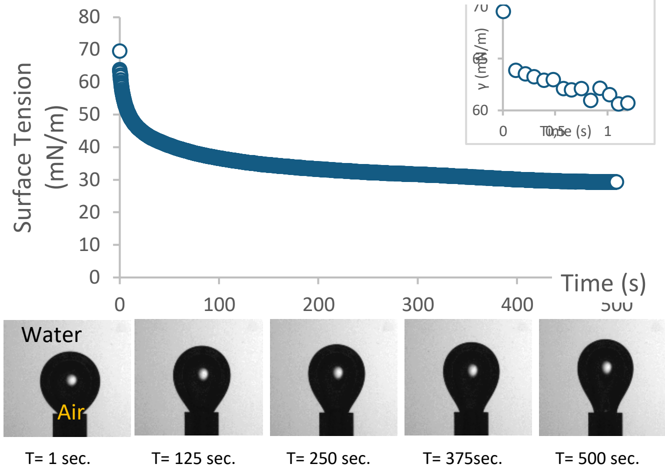
Interfacial rheology (Ex2) measures the viscoelastic modulus often correlated with the stability of foams or emulsions. Interfacial rheology provides a better understanding of the properties of insoluble surfactants, soluble surfactants, soluble surfactants with irreversible adsorption and their reactions at the interface.

TRACKER™ software controls drop volume or area in order to:

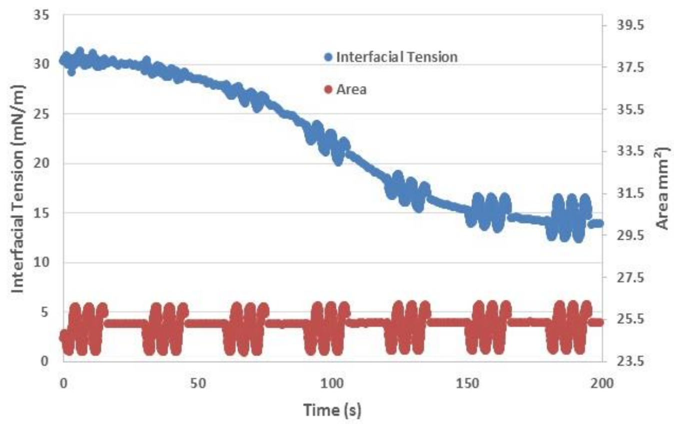
- maintain constant Volume/Area Drop along experiment
- provide a sinusoidal variation whose frequency and amplitude are programmable by the user. These experiments are used to determine the dilatational viscoelastic modulus
- provide linear regimes with sudden variations: pulses.

Data obtained are treated in real time (up to 60 images/s). Setup data, images and results are stored in ITC files and are unalterable.
All measurement results are comparable directly within the software.
The recorded images can be recalculated in post-processing.

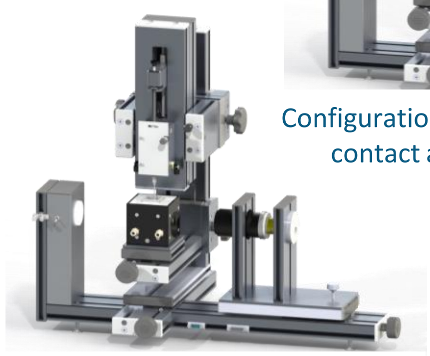
Ex1: Tension at Air/Soap liquid Interface



Ex2: surfactant adsorption at oil/water interface



Configuration for static and dynamic contact angle measurement



Configuration for Surface and Interfacial Tension measurement

Interfacial Dilatational rheology represents a powerful tool to investigate equilibrium and dynamic properties of simple and more complex interfacial layers containing surfactants, proteins, polymers or micro–nano sized particles.

Interfacial rheology allows a better understanding of the properties of surfactants, proteins, polymers or micro–nano sized particles at the interface. Moreover, it enables the **study of adsorption-desorption** phenomena as well as interactions that can take place at the interface. That can reveal crucial information on interfacial dynamics and the contribution of the structure to formulation properties.

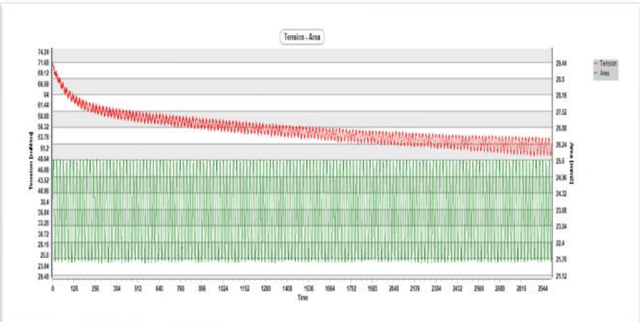
The calculation of the viscoelastic modulus gives a better understanding of how elasticity and viscosity properties of interfaces can be modified and correlated with the stability of foams and emulsions.

Interfacial Rheology by TRACKER™

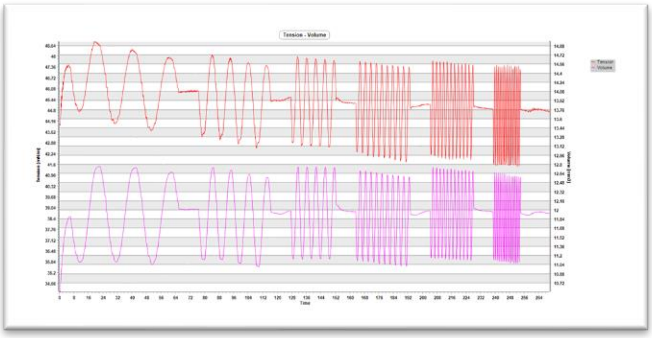
TRACKER™ software enables to precisely control the drop/bubble volume or area and to perform at the same time a sinusoidal variation whose frequency and amplitude is determined by the user. From the basic single-frequency oscillation to complex scenarios including several oscillation steps, all measurement parameters can be set or changed independently, even during measurement:

- Oscillating frequency: from 0.001Hz to 2Hz and up to 10Hz with Piezoelectric module
- Drop volume variation: from +/- 0.1 µl to +/- 100 µl and up to +/- 4 µl with Piezoelectric module
- Volume variation Speed min : 0.01 µl/s
- Volume variation Speed max : 20 µl/s
- Time: drop or bubble area remains constant during oscillations for several hours including at a gas-liquid interface

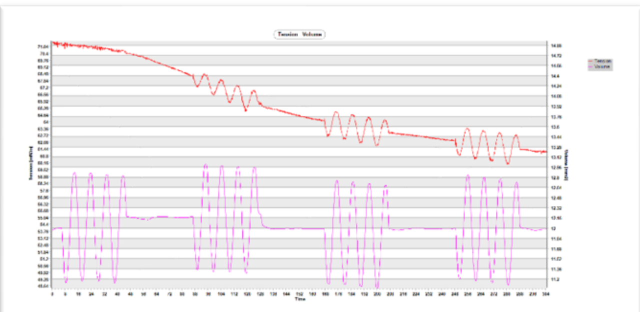
Interfacial rheology measurement examples with TRACKER™



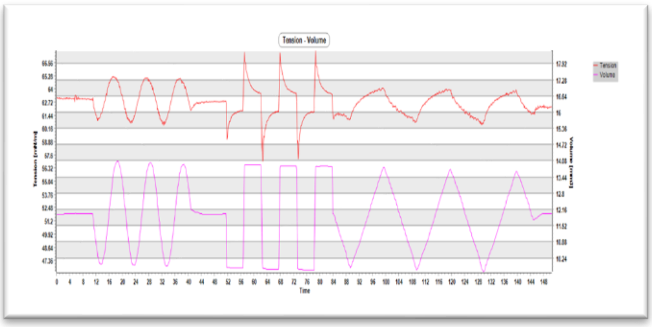
Ex 1: Area regulation during adsorption kinetics



Ex 2: Volume regulation with frequency sweep



Ex 3: Volume regulation with and without oscillation periods



Ex 4: Volume regulation with amplitude sweep

VISCOLEASTIC MODULUS

Viscoelasticity calculation can be performed during the measurement.

$$E = d\gamma/(dA/A)$$

Raw data are recorded, either as drop images or measurements. They can be opened later for re-analyzing and/or reevaluation.

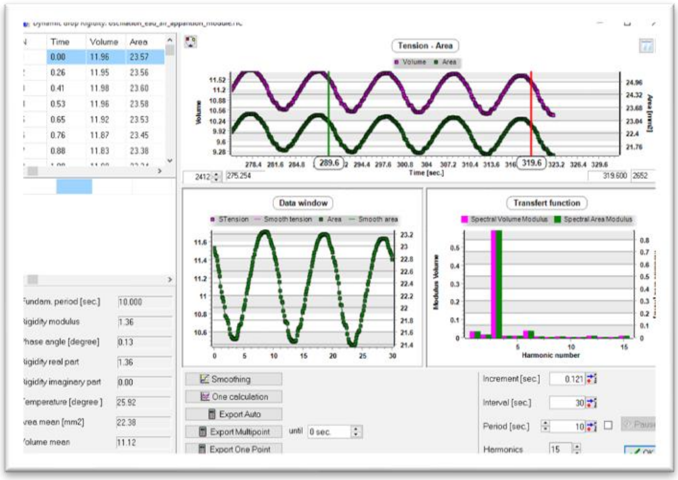
Example of Viscoelastic modulus Calculation

RIGIDITY MODULUS

The calculation of the modulus of rigidity can be performed during the measurement.

$$Rigidity = (dV/V) / (dA/A)$$

It enables to highlight the appearance of membrane on surfaces.



Example of Rigidity modulus Calculation

Compression & dilatation Interfacial rheology

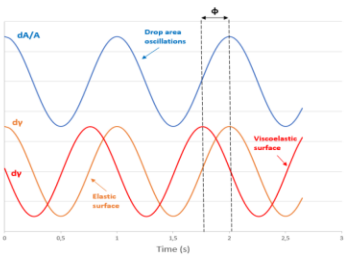
Interface deformation consists of a variation in the interfacial area A (compression & dilatation).

The response of the interface to such deformation is manifested by a variation in surface tension γ.
A viscoelastic modulus can be defined as the increase in surface tension as a function of surface deformation.

$$E = d\gamma/(dA/A) = d\gamma/d\ln(A)$$

The viscoelastic modulus in compression/dilatation is therefore the coefficient of proportionality between a deformation (dA/A) and a surface stress (in N/m), surface tension.

If the deformation varies over time, the ratio between stress and deformation speed with the corresponding surface viscosities can be calculated. If a surface is sinusoidally dilated and compressed at a frequency ω and an amplitude ΔA, and for a viscoelastic surface, a phase shift θ may occur between the change in strain ($\Delta A/A_0$) and the surface tension.



The viscoelastic modulus E becomes a complex number, with a real part E', representing the stored and recoverable energy, and an imaginary part E'', corresponding to the mechanisms that dissipate mechanical energy.

$$E = |E|\cos(\theta) + i|E|\sin(\theta)$$

$$E' = |E|\cos(\theta)$$

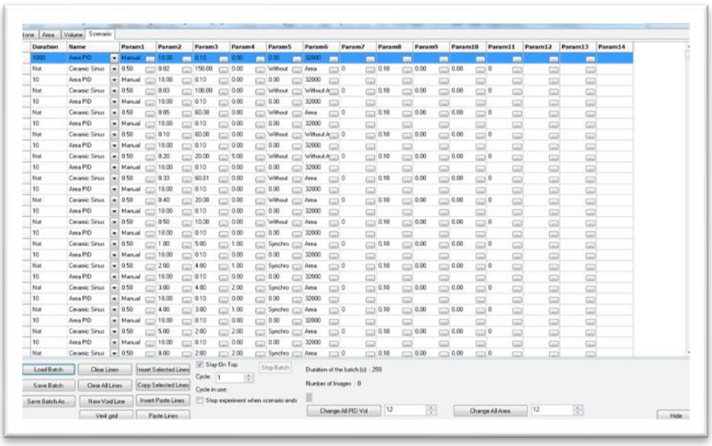
$$E'' = |E|\sin(\theta)$$

BATCH: SCENARIO MANAGEMENT

Batch function enables to write a scenario with an unlimited number of steps or actions to be carried out on the droplet/bubble during the measurement.

All measurement parameters can be set or changed independently, even during measurement:

- Area/volume regulation
- Oscillating frequency
- Oscillation amplitude
- periods
- Time

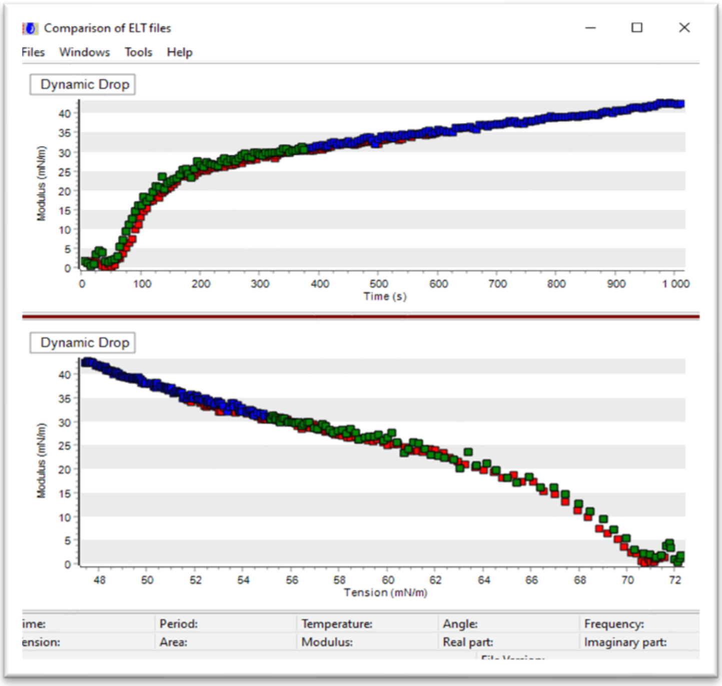


Example of Batch settings

RESULTS COMPARISON

Raw data are recorded, either as drop images or measurements. They can be opened and compared in the software directly. Drop images and measurement data can also be opened later for re-analyzing.

Viscoelastic and Rigidity Modulus Results can also be compared directly in the software without prior data export.



Example of Modulus comparison

TRACKER™

Modules & Options

TRACKER™ *Phase Exchange*

The measurement of surface or interfacial tension provides useful information on the kinetics of adsorption of surfactants. However, it does not allow the study of desorption kinetics. Thus, the question of reversibility of adsorption is difficult to assess by this technique alone.

The PHASE EXCHANGE option completes the technique by measuring the surface or interfacial tension while the dense phase or the drop phase is exchanged during measurement.

The PHASE EXCHANGE option is fully driven by the software. Any measurement can be done while phase exchange: Interfacial tension measurement, oscillations, pulses… Sequences with and without phase exchange can be programmed at a chosen time, changing the speed rate of exchange.

Phase exchange can be performed during measuring or out of measurement.

DENSE PHASE EXCHANGE

The DENSE PHASE EXCHANGE option completes the technique by measuring the surface tension of a bubble or the interfacial tension of a drop formed in a liquid which is exchanged during measurement. The ideal mixing conditions are established by stirring and maintaining a constant flow rate inside the cuvette.

The module is more suitable for exchanging liquid phases. It allows a solution studied in the cuvette to be replaced by another solution while keeping the volume of the drop constant. The user chooses the liquid flow rate, and the software controls the injection cycles.

The surfactant solution studied is either added to the cuvette (loading) or removed from the cuvette by rinsing with water (washing), which makes it possible to directly study the **kinetics of adsorption / desorption** of surfactants such as proteins, polymers… at the interfaces. It also provides information on the interactions between these surfactants at the interface.

DROP PHASE EXCHANGE

The DROP PHASE EXCHANGE option measures the surface tension of a bubble whose gas is exchanged or the interfacial tension of a drop whose liquid is exchanged during experiment, thanks to a double coaxial capillary, while maintaining its volume constant. The exchange rate can be set, and the software controls the injection cycles.

The module is rather suitable for gas exchange, but it can be very useful to study smaller volumes and essential to exchange opaque oils which can only be measured by making a drop of oil in clearer water.

Finally, the DROP PHASE EXCHANGE option allows you to **measure the sequential adsorption of different components at a liquid / liquid interface**, in addition to the classic simultaneous adsorption measurement from a mixed solution. Thus, for example, the movement of pre-adsorbed proteins after the successive addition of another surfactant can be successfully studied by this technique.

Technical specifications	
Compatibility	TRKS, TRKH, TRKCMC
Dense Phase Exchange Rate	0,1 – 20ml / min
Drop Phase Exchange Rate	0,01 -20 µl / s
System	Liquid / Gas - Liquid /Liquid

It can be useful to know the value of the Critical Micellar Concentration (CMC) for a given surfactant and under certain conditions (temperature, pH, ionic strength) because many properties of surfactant solutions change at CMC.

Indeed, quantities such as surface tension, electrical conductivity (for a charged surfactant), osmotic pressure, light scattering vary differently before and after CMC. For example, CMC is interesting:

- If you whether search for the presence of micelle, for example during polymerization reactions
- To predict emulsion stability: if the surfactant concentration exceeds CMC, the emulsion remains more stable
- To understand and choose molecules in formulating
- When the relationship between formulation and skin penetration is studied
- To anticipate the release of encapsulated active ingredients....

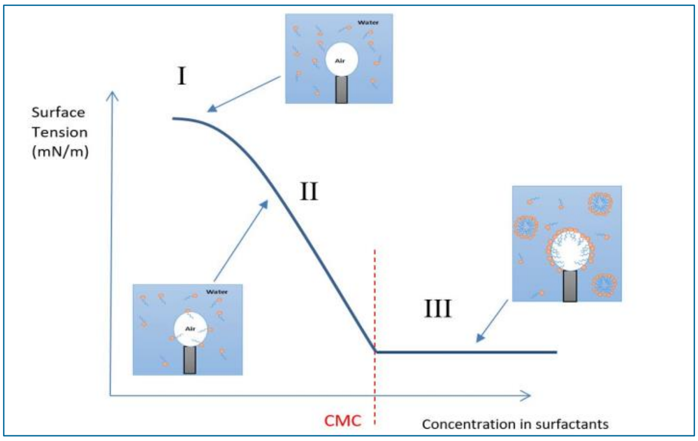
CMC is a good way to characterize and compare surfactants with each other, particularly in terms of temperature and salinity conditions. On the other hand, sweeping in concentration can provide information on the presence of impurities.

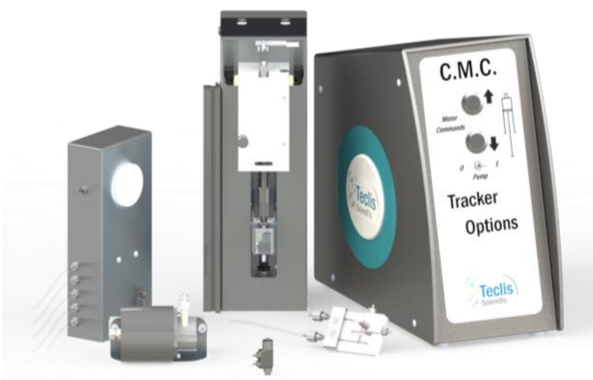
AUTOMATIC CMC

When the surfactant concentration increases in the aqueous phase, some of the surfactant molecules are adsorbed at the water/air surface and the surface tension decreases rapidly (Figure zone I).

Above a certain value, a mono molecular film of surfactant is formed on the surface of the water and the surface tension decreases linearly with the logarithm of the concentration (Figure zone II).

When the surface tension no longer decreases, the critical micellar concentration is reached (CMC). The surfactants in solution are grouped in micelles within the liquid to stabilize each other (Figure zone III).





TRACKER™ CMC automatically determines the critical micellar concentration. The surface tension between the air and a surfactant solution at different concentrations is measured successively. The automatic CMC option allows up to 4 solutions of different concentrations to be used to extend and finely control the concentration range to be scanned. The dosed volume and concentration are fully controlled by an algorithm that calculates the concentration levels in order to optimize the accuracy of the CMC determination.

Low concentration measurements are very useful to define adsorption models, but they can be difficult to perform due to the presence of impurities. To facilitate measurements and eliminate these impurities, TRACKER™ CMC has a panel that controls the automatic cleaning cycles.

Technical specifications	
Compatibility	TRKS, TRKH
Cleaning mode	Automatic
System	Liquid / Liquid – Liquid / Gas

Goniometer & Automatic Drop DEPOSIT Software

The goniometer is a removable platform which allows the horizontality to be adjusted in order to measure the static or dynamic contact angle between a liquid and a solid. The Automatic Drop Deposit software allows to automate the deposition of the drop on the solid surface for a perfect reproducibility of contact angles measurements.

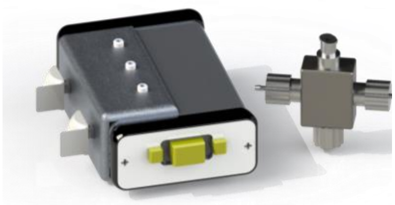
The goniometer is available in a thermostatic version (electric supply or connected to a heating circulator) to measure contact angles up to 200°C.

Technical specifications	
Compatibility	TRKS, TRKH, TRKCMC
System	Liquid /Solid

Pressure sensor to measure Laplace pressure directly

The Bubble pressure in air-liquid systems can be measured in real time and saved by the Software while measuring the surface tension at the same time. This option is particularly interesting:

- When the shape of the bubble is not Laplacian (presence of structured membrane on the surface). In this case the two method of calculation, surface tension by optic and surface tension by pressure will not give the same result. It can be a way to see that the shape is not LAPLACIAN and that the interface is not "liquid".
- When you want to have very high-speed measurement (oscillation with the piezo).



Technical specifications	
Compatibility	TRKS, TRKH, TRKCMC
System	For Liquid/gas systems only

Piezoelectric cell for higher frequency drop oscillation

The **piezoelectric cell** is a module which is connected to the syringe.

This option makes it possible to **oscillate gas bubble at different frequencies** (0,01Hz to 10Hz). During oscillation, no data is displayed, since the maximum number of images (60 per second) is being captured for subsequent analysis.

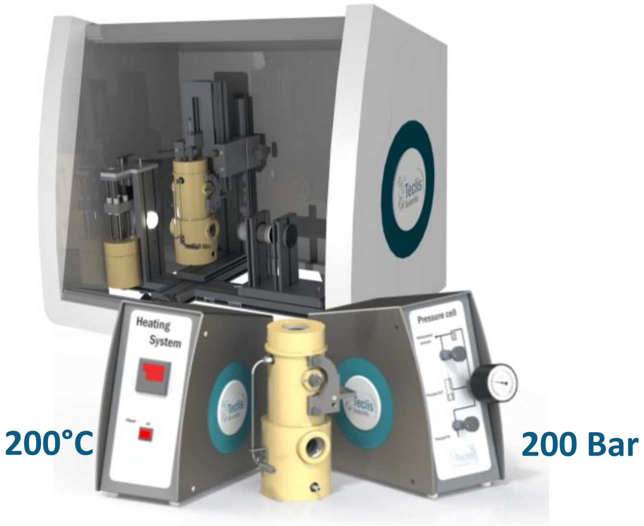
After oscillation is finished, the results are calculated and displayed.

Technical specifications	
Compatibility	TRKS, TRKH, TRKCMC
Frequency Range	0,01Hz – 10Hz
System	For Liquid/gas systems only

TRACKER™ HIGH PRESSURE

designed to characterize surface & interfacial properties in demanding conditions

TRACKER™H is standard automatic drop Tensiometer, equipped **with a removable pressure cell** that allows to measure superficial/interfacial tension and contact angle up to **200 bar and 200°C .**



The pressure cell is easily attached to the TRACKER™. It encloses the syringe and the cuvette for handling the sample under a controlled atmosphere.

TRACKER™H is designed to measure gas/liquid or liquid/liquid or solid/liquid interfaces with both configurations, pendant drop or rising drop**.** Thanks to the rotative platform, several drops can be successively placed on or beneath a solid to make several contact angle measurements under pressure without opening the pressure cell.

The syringe piston is accessible from outside the cell and can be automatically controlled. The cell is connected to a pressure network, a gas cylinder or a compressor via the gas control box.

A separated thermocouple measures temperature of liquid inside the cell. Temperature control is driven by using an external circulating bath or electric resistances. A control unit supplies power to electrical heaters and displays set and actual temperature of the environmental chamber jacket.

The module has been designed to be easily dismantled for cleaning.

Drop shape analysis is made through sapphire windows. Both temperature and pressure parameters as well as measurement set up are controlled by the software. Data are calculated in real time.

Measuring devices

Data & Measurements

- Surface Tension (liquid/gas)
- Interfacial Tension (liquid/liquid)
- Contact angle & Surface Energy (liquid/solid)
- Advancing and receding Contact angle
- Interfacial rheology – Viscoelastic modulus
- Coefficient of rigidity
- Temperature / Pressure

Applications

- Supercritical CO^2
- Petroleum, bitumen experiments
- Smelt polymer
- Contact angle under pressure
- Compatible with methane

Technical specifications	
Pressure / T°	Up to 200bar / 200°C
Gas	Supercritical CO^2, nitrogen, argon, air, CO_2 …
Connectors	Stainless steel tube (1/8”OD, 1m length) to connect pressure cell to the gas box

TRACKER™ HTHP - *Pressure Cell from 350 to 700bar*

TRACKER™ HTHP has been designed to measure superficial or interfacial tensions, contact angle and study interfacial rheology for most demanding applications.

TRACKER™ HTHP can measure under a temperature up to 200°C and a pressure up to 700 bar. High pressure cell's design has been **certified by CETIM*.**

TRACKER™ HTHP is modular and fully polyvalent. It can measure:

- Interfacial tension between Liquid/Liquid, Liquid/Gas using **pendant or rising drop** method.
- Contact angle of a Liquid placed **on or beneath** a solid surface.
- Interfacial rheology with frequency and amplitude regulation of the Volume/Area of the drop and calculation of the Viscoelastic Module.
- Advancing and receding contact angle of a liquid placed on or beneath a Solid.

TRACKER™ HTHP is compatible with all nonexplosive gases and Supercritical CO_2. The instrument is available in 3 maximum pressure versions: 350 / 500 / 700 bar.

200°C

700 Bar

Technical specifications	
Pressure	Up to 700 bar
T°	Up to 200°C
Gas	Nitrogen, argon, air, CO_2, supercritical CO_2
Gas Box	Pressure relief and vent valves – Connections for gas line
Syringe	Syringe 2,5ml, Hastelloy C276 modified
Cuvette	25 x 25 X 32 mm

Measurement device

The pressure cell encloses the syringe, the needle, the cuvette and the parts allowing to adapt to various applications: pendant drop, rising drop, sessile drop... The entire device is modular, easy to use and easy to clean.

Contact angle measurement can be made with a liquid drop placed on or beneath a solid surface. A rotating platform allows several drops to be successively placed to **perform several contact angle measurements under pressure without opening the pressure cell**.

The syringe is specially designed to handle drops and bubbles under pressure with precision. It is directly and constantly controlled by the software to regulate very precisely the volume and area of the drop/bubble or to make oscillations during the experiment, in order to obtain interfacial rheology data.

The pressure cell is not removable from the device. TRACKER™ HTHP can be used without pressure, but only with the cell.

Optical system

TRACKER™ HTHP is equipped with a monochrome CCD camera with a resolution of 640x480 pixels and a tele-centric lens. The camera records up to 60 frames per second (fps) covering most applications. When very fast phenomena are studied, a fast camera (up to 600 fps) is provided.

A light source illuminates the sample in a homogeneous and constant manner. The grayscale variation of one pixel only varies by ± 10 grayscales out of 256. The light source has 2 luminous intensities to adapt to solutions with higher optical density.

Drop shape analysis is made through sapphire windows.

Temperature and pressure system

TRACKER™ HTHP is equipped with a booster to increase the pressure up to 700 bar and an oil circulating bath to increase the temperature up to 200 °C.

TRACKER™ HTHP is a full set instrument. The measuring device, the optical system and the temperature and pressure system are gathered in a compact, mobile chassis forming a stand-alone measuring instrument that does not require the addition of other equipment.

*Centre Technique des Industries Mécaniques www.cetim.fr

Software

TRACKER™ HTHP is automated to perform accurate measurements, produce reliable results and perform reproducible manipulations.

TRACKER™ HTHP software controls both temperature and pressure parameters as well as measurement settings. Data obtained are treated in real time.

The software uses algorithms to analyze the drop's profile and to fit it with models based on the Young-Laplace equation in order to determine surface tension, interfacial tension or contact angle.

Surface and Interfacial Tension measurements are made with both rising or pendant liquid drops or gas bubbles depending on the density of the fluids. It also controls drop's volume or area in order to:

- maintain constant Volume/Area Drop along experiment
- provide a sinusoidal variation whose frequency and amplitude are programmable by the user. These experiments are used to determine the dilatational viscoelastic modulus
- provide linear regimes with sudden variations: pulses.

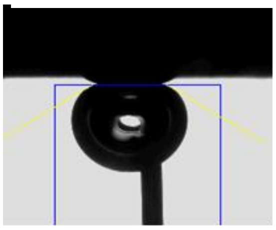
Tracker HTHP software measures static and Advancing and receding contact angle of a liquid drop placed on or beneath a solid surface under pressure (Ex 3). Thanks to the rotative platform, several drops can be successively placed to make several measurements under pressure without opening the pressure cell.

Setup data, images and results are stored in ITC files and are unalterable. All measurement results are comparable directly within the software.

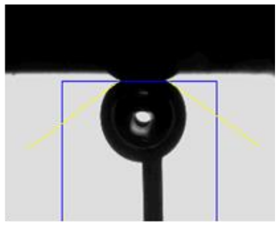
The recorded images can be recalculated in post-processing.

Data & Measurements
• Surface Tension (liquid/gas)
• Interfacial Tension (liquid/liquid)
• Contact angle & Surface Energy (liquid/solid)
• Advancing and receding Contact angle
• Interfacial rheology – Viscoelastic modulus
• Coefficient of rigidity
• Temperature
• Pressure

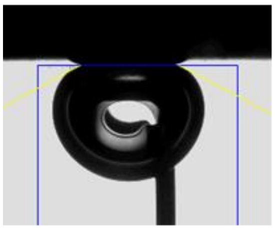
Ex3:Measurement of advancing and receding contact angles at low and high pressures of CO_2 at 70°C (caprock substrate)



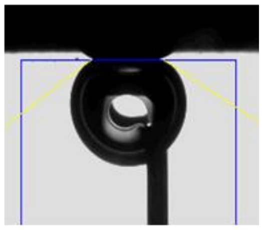
11 bar advancing (148°)



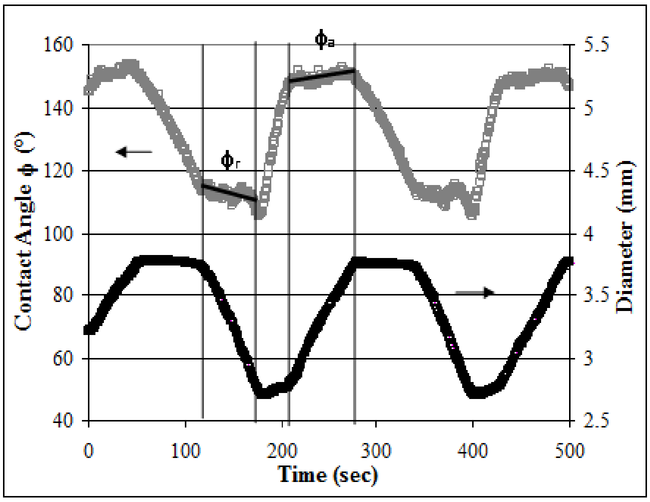
11 bar receding (147°)



155 bar advancing (153°)



155 bar receding (147°)



SPE 113353-PP
Capillary Alteration of Caprocks by Acid Gases
Virenkumar Shah, University of Pau and TOTAL SA; Daniel Broseta, University of Pau ; Gerard Mouronval,
Copyright 2008, Society of Petroleum Engineers

Applications

- EOR
- Supercritical CO²
- Petroleum, bitumen experiments
- Smelt polymer
- Contact angle under pressure
- Compatible with methane

TRACKER™

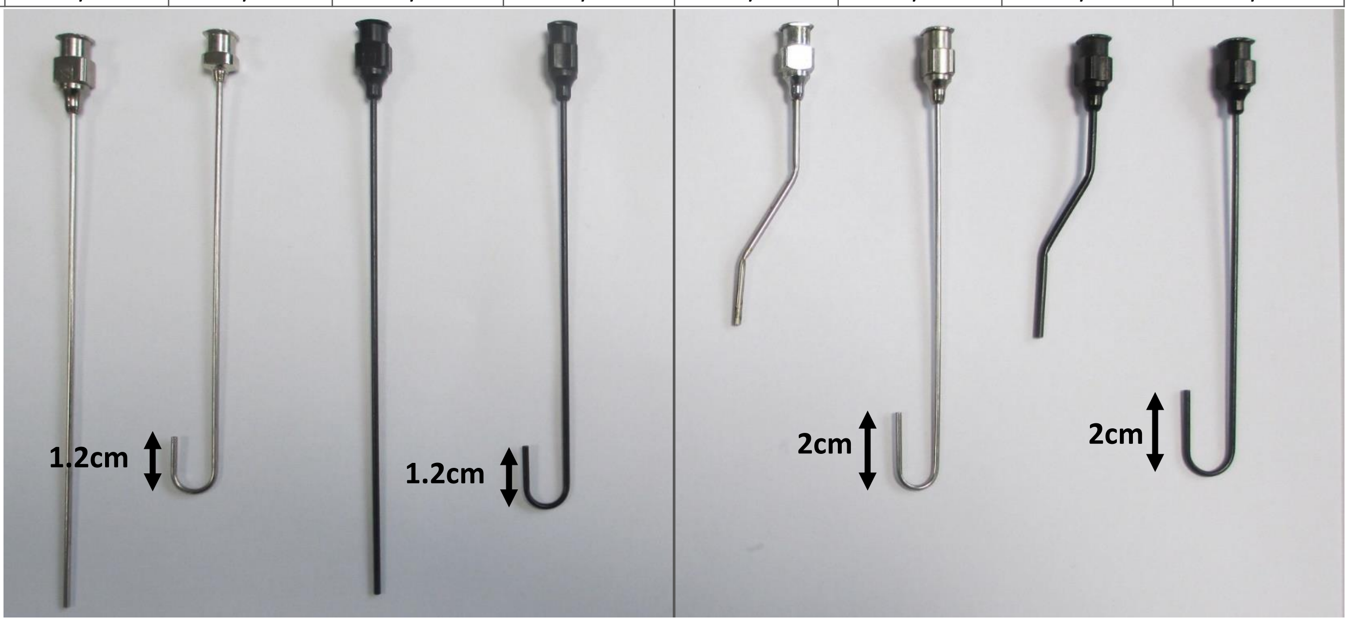
Consumables & Accessories

Needles

All needles are used for interfacial/superficial tension and contact angle measurements whether rising or pendant drop/bubble. When the dispensed liquid/gas is denser than the liquid/gas inside the cuvette, straight needles are recommended. Otherwise curved needle are preferred. Curved needles have a J-shaped bend to orient the tip upward. Needles and Luer-lock hubs are made of type 304 stainless steel.

To order, please indicate the gauge, length and configuration needed

	FOR STANDARD				FOR PRESSURE CELL			
Shape	Straight	Curved	Straight+ Teflon Coat	Curved+ Teflon Coat	Bent	Curved	Bent+ Teflon Coat	Curved+ Teflon Coat
Length	100mm/4'	100mm/4'	100mm/4'	100mm/4'	51mm/2'	100mm/4'	51mm/2'	100mm/4'
Gauge / internal diameter (mm)	G20 / 0.60	G20 / 0.60	G20 / 0.60	G20 / 0.60	G20 / 0.60	G20 / 0.60	G20 / 0.60	G20 / 0.60
	G18 / 0.84	G18 / 0.84	G18 / 0.84	G18 / 0.84	G18 / 0.84	G18 / 0.84	G18 / 0.84	G18 / 0.84
	G16 / 1.19	G16 / 1.19	G16 / 1.19	G16 / 1.19	G16 / 1.19	G16 / 1.19	G16 / 1.19	G16 / 1.19
	G14 / 1.60	G14 / 1.60	G14 / 1.60	G14 / 1.60	G14 / 1.60	G14 / 1.60	G14 / 1.60	G14 / 1.60



Optical Glass Cuvettes

STANDARD	Size L / w / H (mm)	Capacity
CUV5	23 x 15 x 40	5mL
CUV5 (Tracker<2005)	22 x 12 x 45	5mL
CUV25	30 x 30 x 70	25mL

SYRINGES						
Volume	**STANDARD before 2005**	**Model**	**STANDARD**	**Model**	**PRESSURE CELL**	**Model**
50 µL			**SGE50**	SGE		
100 µL			**SGE100**	SGE		
250 µL	**EX250**	Exmire	**SGE250**	SGE	**PC-H250**	Hamilton
500 µL	**EX500**	Exmire	**SGE500**	SGE	**PC-H500**	Hamilton
1000 µL	**EX1000**	Exmire	**SGE1000**	SGE	**PC-H1000**	Hamilton
2500 µL	**EX2500**	Exmire	**SGE2500**	SGE	**PC-H2500**	Hamilton

All syringes have borosilicate glass barrels and Teflon plungers. The end terminations Luer-lock tips are also made of Teflon.

STANDARD CONSUMABLES & ACCESSORIES	
CALS	Set of 2 Optical Calibration spheres (Diam 3mm and 4mm +/- 0.0001 mm)
ITJ-5	Insulated Thermostatic Jacket for Cuvette 5ml including Temperature control (up to 90° C) and stirring by magnetic bar
ITJ-25	Insulated Thermostatic Jacket for Cuvette 25ml including Temperature control (up to 90° C) and stirring by magnetic bar
ITSH90	Insulated Thermostatic Syringe Holder -Temperature control up to 90° C
ITSJ90	Insulated Thermostatic Syringe & needle Jacket -Temperature control up to 90° C

CONSUMABLES & ACCESSORIES FOR PRESSURE CELL	
PAWIN	Portholes for the pressure cell 200
PTFT	Teflon O-ring for syringe
PTFR	Teflon support for syringe - Length : 2cm
PTFS	Teflon support between needle and syringe - Length : 1cm
PC-NBR-OR	Set of NBR O-rings for pressure cell (PCL200-200) (1) 16*2 mm / (2) 24*2 mm / (1) 4*2 mm / (1) 46*2 mm / (2) 30*2 mm
PC-FKM-OR	Set of Viton FKM O-rings for pressure cell (PCL200-200) (1) 16*2 mm / (2) 24*2 mm / (1) 4*2 mm / (1) 46*2 mm / (2) 30*2 mm
PC-FFKM-OR	Set of FFKM O-rings for pressure cell (PCL200-200) (1) 16*2 mm / (2) 24*2 mm / (1) 4*2 mm / (1) 46*2 mm / (2) 30*2 mm

O-RINGS CONDITIONS OF USE	NBR	FKM	FFKM
Temperature	80° C	220° C	250° C
Supercritical conditions	Yes	No	Yes
Chemical compatibility	Not to used with most of solvents (ketone, toluene, chloroform...) Good compatibility with acid and base		Full compatibility

Technical Features

	TRACKER™ Standard	TRACKER™ CMC	TRACKER™H Pressure Cell 200bars	TRACKER™ HTHP 350-700bars
Reference	TRK-S	TRK-CMC	TRK-H	TRK-HTHP
Tension Accuracy mN/m	0,1	0,1	0,1	0,1
Drop/bubble automatic control	Yes	Yes	Yes	Yes
Contact angle accuracy	0,1°	0,1°	0,1°	0,1°
Temperature	Up to 90° C	Up to 90° C	Up to 200° C	Up to 200° C
Pressure	Atmospheric	Atmospheric	1-200bar	1-700bar
Oscillation Max.	1hz	1hz	1hz	1hz
Piezoelectric module	Optional	Optional	Optional	No
Oscillation with Piezo	10hz	10hz	10hz	No
Pressure Sensor	Optional	Optional	Optional	No
Dense Phase Exchange	Optional	Optional	Optional	No
Drop Phase Exchange	Optional	No	Optional	No
CMC	Optional	Yes	No	No
Goniometer	Optional	Optional	Optional	No
Syringe	SGE 50µl to 1 ml		Hamilton 1 to 2,5 ml	Hastelloy C276 2,5 ml
Needles	Stainless steel ID from 0.6 to 1.6 G20 to G14	Stainless steel ID from 0.6 to 1.6 G20 to G14	Stainless steel ID from 0.6 to 1.6 G20 to G14	Stainless steel ID from 0.6 to 1.6 G20 to G14
Optical Glass Cuvette Size L / w / H (mm)	30x30x70 or 23x15x40	30x30x70 or 23x15x40	30x30x70	25x25x32
Chemical compatibility	No restriction		Cell made of Hastelloy required depending on chemicals used	
Instrument Dimensions L / w / H (cm)	79*57*77	79*57*77	79*57*77	83*91*186 Incl. pressure booster and heating circulator
Weight (full instrument)	≈ 30kg	≈ 30kg	≈ 35kg	≈ 300kg
Camera definition	USB 2 : 640*480 px, 60 fps USB 3 : 720*540 px, 5390 fps Other video camera on demand			
IS compatibility Computer not included	Windows XP-10 32-64 bits	Windows XP-10 32-64 bits	Windows XP-10 32-64 bits	Windows XP-10 32-64 bits

About US

TECLIS Scientific is a French company specializes in measuring instruments and services for Interface Science for more than 25 years.

TECLIS Scientific designs and markets analytical equipment and provides scientific expertise to characterize dispersed systems such as foams and emulsions and to characterize solids surface energy. .

An advanced technology software based on image analysis is applied in all instruments. A complete range of measuring instruments has been developed to study and understand interfaces properties of liquid/liquid, solid/liquid and gas/liquid interfaces.

TECLIS Scientific uses innovative engineering to create efficient instruments and software solutions which are easy to use for researchers.

Measuring Instruments for Interface Science

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