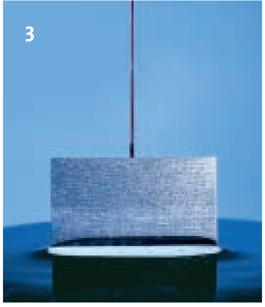
DCAT 11/DCAT 11HR

Dynamic contact angle measuring instruments and tensiometers

dataphysics



DCAT 11 and DCAT 11HR

Dynamic contact angle measuring instruments and tensiometers

Advanced equipment for classic and new measuring methods
The DCAT 11 is equipped with a high-tech weighing system, new efficient microelectronics and MS Windows software. It is the universal tensiometer system for classic measuring methods such as the exact determination of surface and interfacial tension of liquids. It was, however, also developed as a dynamic contact angle measuring instrument for the application of new measuring methods such as measurement of the dynamic wetting properties of different solid surfaces.

As a result, the wetting forces and capillarity effects are measured very precisely and at a high speed, with a resolution in the microgramme range. Together with the integrated "Monolith" weighing system, the electronics specifically developed for the DCAT 11 set new standards. The weighing resolution is 10 µg with a measuring speed of up to 50 measuring values/s and a minimal relative speed of the solid sample against the liquid surface of 2 µm/s. The product properties of the DCAT 11 permit its use in interface-chemical applications which so far were excluded from an exact analysis with electronic universal tensiometers.

What you can measure with the DCAT 11
Among the typical applications of the DataPhysics DCAT 11 are:

- the dynamic adsorption and contact angle measurement on wettable powders according to the modified and the extended Washburn method,
- the determination of the advancing and the receding contact angle on prismatic or cylindrical solids due to the Wilhelmy method,
- the dynamic contact angle measurement on single fibres, fibre bundles, hairs and membrane tubes from a diameter of about 10 µm,
- the surface energy analysis according to a multitude of evaluation models, e.g. Owens-Wendt, Wu, acid-base, extended Fowkes, Zisman and others on the basis of the measured contact angles with various test liquids.

Fully automatic tensiometry for many applications
An enormous variety of surface-active substances – especially commercial surfactants – are ingredients for the products of our daily life. Detergents as well as liquid pharmaceutics are representative of such products. Especially for the examination of the effect and efficiency of surfactants, the DCAT 11 offers particular user value:

1
Measurement of the surface tension with a Du Noüy ring according to DIN 53914 and ASTM-971

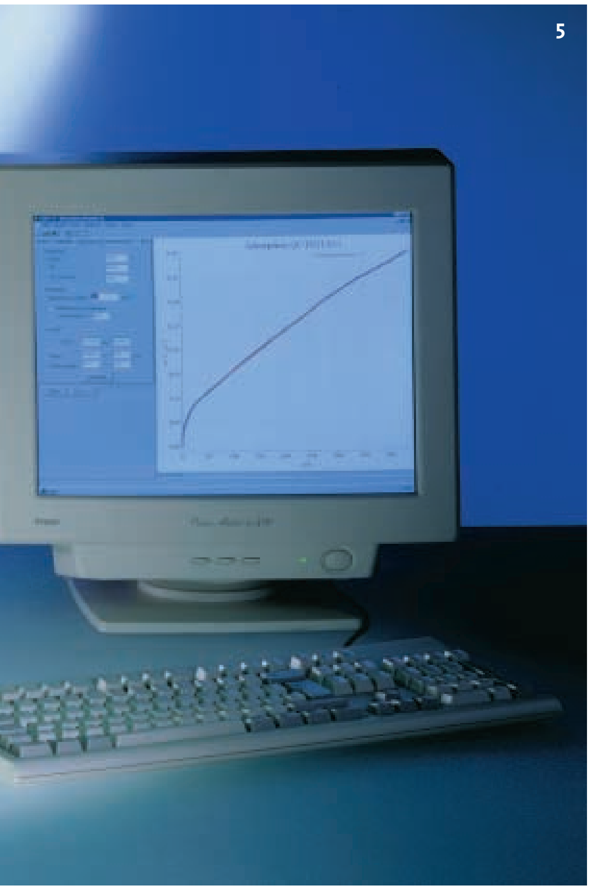
2
Glass tube for the powder contact angle measurement according to Washburn

3
Measurement of the dynamic contact angle and the surface tension according to the Wilhelmy plate method

4
Dynamic contact angle measurement on fibres according to the dynamic Wilhelmy method

$$F_W = L_W \gamma_{LV} \cos \Theta$$

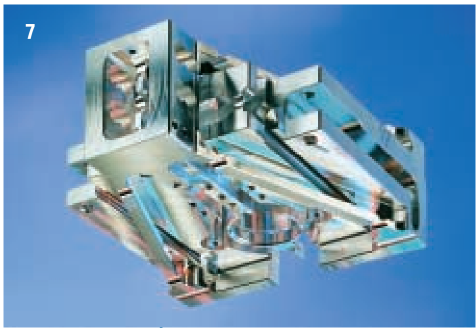
The Wilhelmy wetting force on solids



The technical equipment and functional design ensure easy work
In the development of the DCAT 11, experienced users stood behind the realization of the system concept that points the way ahead. A large and clearly structured graphic display provides online information about the current weighing values, the temperature of the two measuring inputs and the micrometer-precise position of the liquid temperature controlled sample vessels. The electronic positioning of the sample vessel by means of software or keys on the basic unit of the compact instrument ensures convenient and safe work during sample preparation.

The modular electronic system of the DCAT 11 can easily be extended with bus-compatible components. A second temperature channel and an optional automatic dosing system can be used for the control or software-supported addition of liquid volumes during the CMC determination. The control and evaluation software SCAT for the DCAT 11, which runs under MS Windows 9x/NT/2000, will not only smoothly work with standard software such as MS Excel, MS Word or Microcal Origin™, it also offers to the user the advantages of a graphically oriented, intuitively usable software package with statistical evaluation options.

If you need more – DCAT 11 HR
If the measurement of smallest position differences is required, for instance in the analysis of microstructured samples, optionally the incremental position measuring system HR 11 is used. It increases the position resolution of the DCAT to the range of the visible light wavelength, i. e. 500 nm. To decide on Dataphysics DCAT 11 means to decide on state-of-the-art technology.



5
DCAT 11 with glass tube for powder samples to measure the adsorption behaviour

6
Illuminated sample chamber with inert gas connection, temperature control device TV 70, sample vessel GS 70 and Du Noüy ring.

7
"Monolith" precision weighing module of the DCAT 11 (by kind permission of Sartorius AG, Göttingen)

- fully automatic determination of the critical micelle concentration and other surface-chemical characteristics of pure surfactants derived from the CMC,
- the analysis of the synergy effects of surfactant mixtures,
- the measurement of the static or time-dependent surface tensions of liquids as well as the determination of the static interfacial tension between liquids according to the ring, plate or Lenard frame method.

In the table on page 6 you find a detailed summary of the tasks, measuring methods and test results.

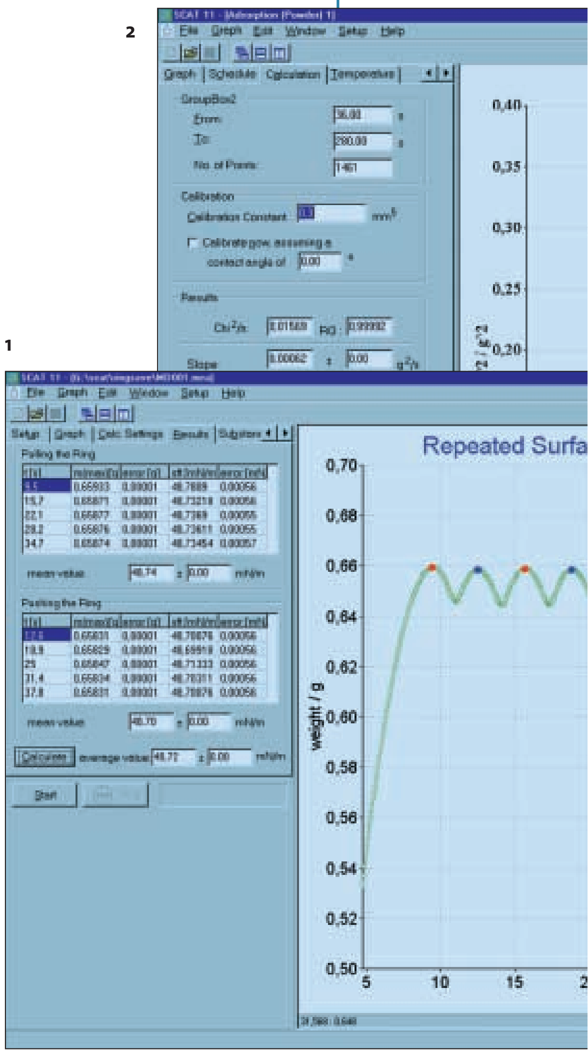
1
Repeated ring measurements on a pure test liquid
2
Adsorption test on powder
3
Liquid data base

The SCAT software

For efficient work, rapid evaluation and expressive presentation of results

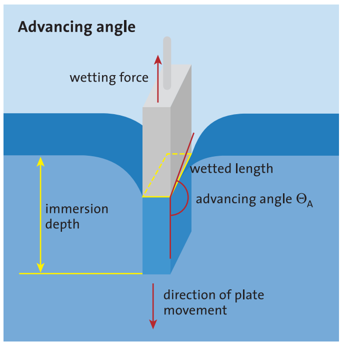
2

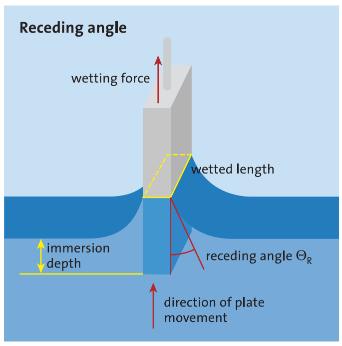
1



The system software SCAT under MS Windows
For the DCAT 11 the software packages SCAT 11 and SCAT 12 are available. They were specifically developed for the two main fields of application of the instrument and run under the current MS Windows versions (9x/NT/2000). Both software packages have the option of an automatic program run “at the touch of a key“ for easiest operation as well as the individual setting of parameters for each single measurement section. The SCAT 11 has all the advantages of a graphically based measurement of wetting properties and the surface energy analysis of solids, while the SCAT 12 offers to the user the known tensiometrically based measuring and evaluation methods for liquids and especially surfactant solutions.
A customer-specific extension of the SCAT software can easily be achieved with up-to-date, object-oriented development tools. Ask us about it.

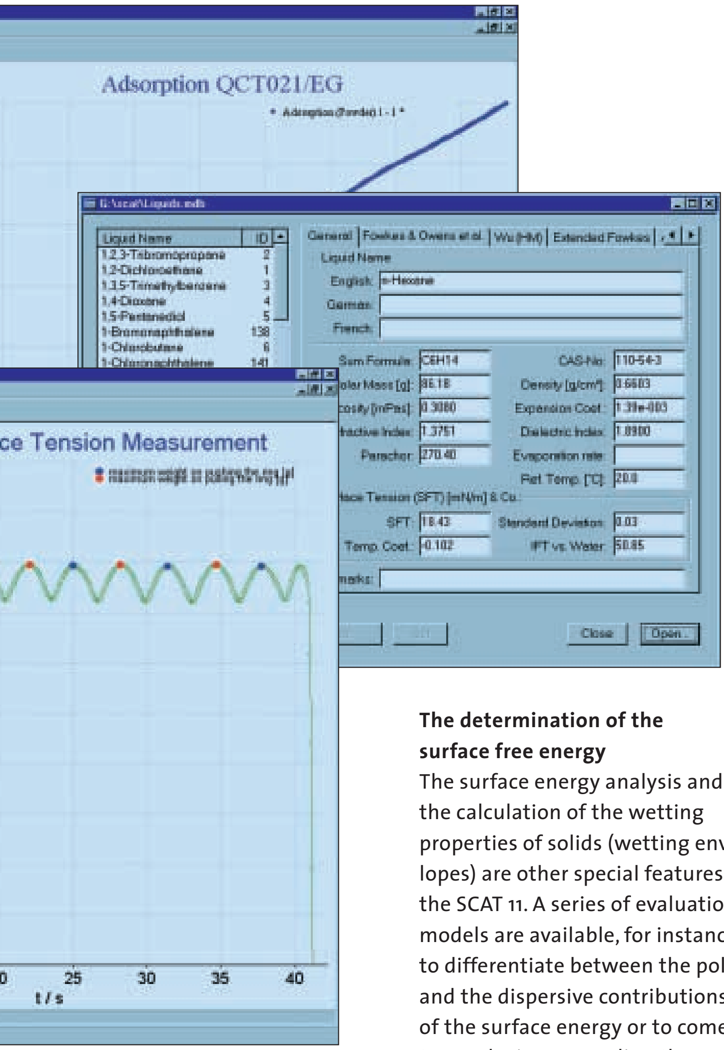
To study dynamic wetting properties – the SCAT 11 software
The SCAT 11 software completes the DCAT 11 to a dynamic contact angle measuring instrument and adsorption analyser. With the aid of the program, position- and speed-dependent advancing and receding contact angles can be measured on prismatic and cylindrical solids with the dynamic Wilhelmy method. Thin single fibres from a diameter of approx. 10 µm as well as fibre bundles, hairs and membrane tubes can be successfully characterized. Special sample holders for instance for test plates or single fibres ensure an easy sample preparation. The buoyancy-corrected measurement of the occurring forces during the wetting and dewetting process versus the test liquids then supplies – either automatically or manually controlled – the dynamic advancing or receding contact angle, usually an important initial parameter to determine the surface energy.





$$\frac{d\mu(t)}{dt} = b(\mu)\left(\frac{\mu_\infty}{\mu(t)} - 1\right)$$

The Extended Washburn Equation to describe adsorption processes



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The determination of the surface free energy

The surface energy analysis and the calculation of the wetting properties of solids (wetting envelopes) are other special features of the SCAT 11. A series of evaluation models are available, for instance to differentiate between the polar and the dispersive contributions of the surface energy or to come to conclusions regarding the wettability of solids versus other liquids. The available analysis models are: Fowkes (geometric mean), Wu (harmonic mean), Extended Fowkes (including hydrogen bonds), Zisman (critical surface tension), Owens-Wendt (dispersive & polar), van Oss & Good (acid-base theory), and Neumann's equation of state (EOS).

The calculated polar and dispersive contributions moreover permit the presentation of parametric limiting curves for those areas of surface tension components that result in a complete wetting of the solid under examination. These so-called wetting envelopes represent an important support in the prediction of spreading processes. Statistical statements for instance regarding the tolerances for the calculated surface energies and the correlation coefficients of the analysis model used complete the expressiveness of the calculated model parameters. The program part Surface Energy Analysis works with an integrated, very comprehensive and easily extendable liquid data base.

Adsorption measurements on powders and fibre bundles

Particular importance within the SCAT 11 software is attributed to the measurement of contact angles on powders and fibre bundles according to the so-called Washburn method. The samples to be examined are mainly pharmaceutical powders, pigments, fillers, varnish additives, ceramic powders or also instant food as well as various natural or synthetic fibres including fabrics and non-woven products.

Especially the exact knowledge of the wetting properties of the mentioned powders is of high practical relevance for a multitude of applications. Glass sample tubes with a permeable glass filter permit the test liquid to penetrate the powder poured into the tube. This process can be detected and recorded by the SCAT 11 software with a high time resolution of up to 50 measuring values/s. The subsequent evaluation of the increase in weight according to the modified or the extended Washburn equation permits the determination of contact angles even for samples that so far could often not be analysed. In analogy, special sample holders for fibre bundles, fabrics and non-wovens are exactly the right accessories for an easy sample preparation to measure the adsorption properties of such materials.

The surface and interfacial tension – wetted lengths

The Wilhelmy plate method is traditionally used to measure the static surface tension of an unknown test liquid on a sample plate with a known contact angle. Therefore, the application of this principle by means of a platinum plate PT 11 according to DIN 53914 can be handled by the SCAT 11 just as well as the determination of the wetted length of a prismatic or cylindrical sample body by means of a known, completely wetting test liquid.

Density – an important test parameter

The adsorption measurements on powders, fibres or other sample specimens as well as the determination of the surface and interfacial tension according to the Du Noüy ring method require the density of the measured or the test liquid at a certain temperature as an important test parameter. You therefore have the possibility to measure the density of liquids according to Archimedes' principle, using precise silicon reference specimens.

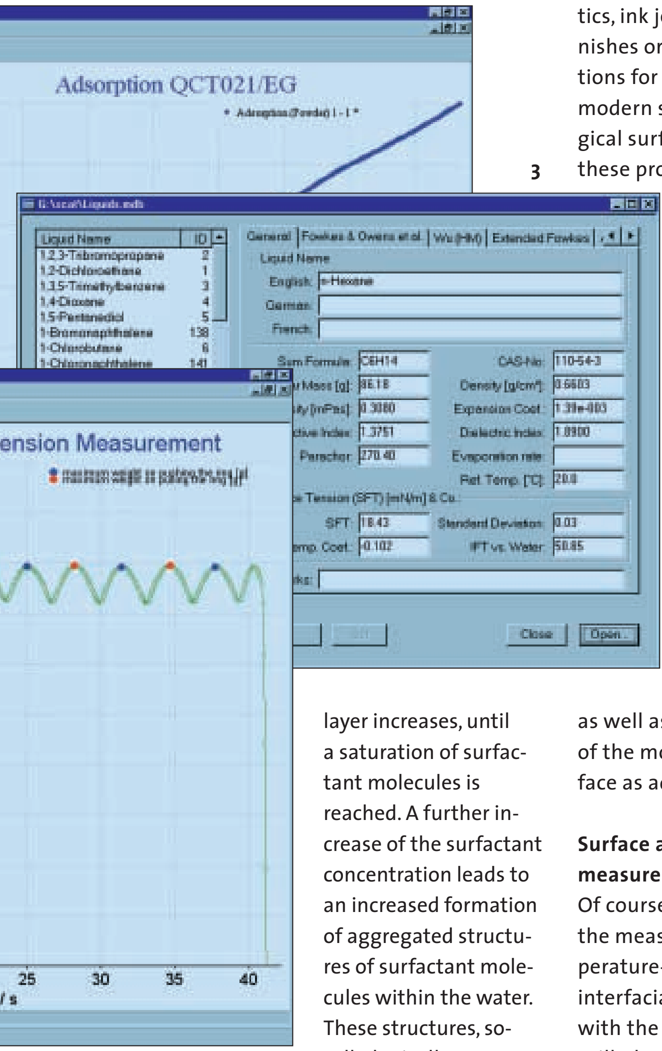
Tasks – Measuring methods – Test results

	Tasks for the DCAT 11	Measuring method	Test result: Interface-specific parameters Measuring ranges of typical instrument systems
For solids – SCAT 11	• Determination of the contact angle of powders and fibre bundles • Determination of the adsorption behaviour of liquids on wettable materials	Modified Washburn method	• Measurement of the average dynamic contact angle $\bar{\Theta}_A$ based on the Modified and the Extended Washburn Equation • Measurement of the adsorption speed of a liquid amount Δm_L as a function of time $\Delta m_L(t)$ • Calculation of the critical surface tension γ_S^C as well as the surface free energy γ_S as with the single fibre contact angle method possible from $\bar{\Theta}_A$ • Typical measuring range $\bar{\Theta}_A$: 0 ... 85°
	• Determination of the dynamic contact angle (advancing and receding angles) of liquids on fibres and membrane tubes • Determination of the wetted circumference/ diameter of fibres and membrane tubes	Single fibre contact angle method (special case of the Wilhelmy method)	• Measurement of the dynamic contact angle Θ^{dyn} as a function of the immersion speed v of the fibre into or out of a test liquid: - as advancing angle $\Theta_A(v)$ - as receding angle $\Theta_R(v)$ • Measurement of the difference between advancing and receding angle (contact angle hysteresis)) $\Delta\Theta_{AR}(v)$ • Determination of the wetting circumference L or the average fibre diameter D by means of a completely wetting liquid ($\Theta \approx 0°$) • Calculation of the critical surface tension γ_S^C as well as the surface free energy γ_S from $\Theta_A(v)$ possible: Determination of the dispersive γ_S^d as well as the non-dispersive γ_S^{nd} parts (e.g. polar parts γ_S^p, acid-base parts $\gamma_S^{\oplus}/\gamma_S^{\ominus}$, hydrogen bond parts γ_S^H) from contact angle measurements with different test liquids • Typical measuring ranges Θ: 0 ... 85°, 95 ... 180° • Typical measuring range γ_S: 10 ... 1000 mN/m
	• Determination of the advancing and receding contact angles of prismatic and cylindrical samples	Dynamic Wilhelmy method (special case of the Wilhelmy method)	• Measurement of the dynamic contact angle Θ^{dyn} as a function of the immersion speed v of the sample: - as advancing angle $\Theta_A(v)$ - as receding angle $\Theta_R(v)$ • Measurement of the difference between advancing angle and receding angle (contact angle hysteresis) $\Delta\Theta_{AR}(v)$ • Determination of the wetting circumference by means of a completely wetting liquid ($\Theta \approx 0°$) • Calculation of the critical surface tension γ_S^C as well as the surface free energy γ_S as with the single fibre contact angle method possible from $\Theta_A(v)$ • Typical measuring range γ_S: 10 ... 1000 mN/m
	• Determination of the density of liquids	Archimedes' principle	• Measurement of the liquid density as a function of temperature $\rho_L(T)$ (to determine sample parameters for adsorption measurements) • Typical measuring range $\rho_L(T)$: 0.50 ... 2.50 g/cm³
For liquids – SCAT 12	• Determination of the static surface and interfacial tension of liquids • Determination of the critical micelle concentration (CMC) of surfactants and of the synergism effect of surfactant mixtures	Du Noüy ring method	• Measurement of the static interfacial or surface tension γ_L as a function of time $\gamma_L(t)$,temperature $\gamma_L(T)$ or the surfactant concentration $\gamma_L(c)$ to determine the CMC and other derived values (e.g. space requirement of a molecule on the surface A_M, surface excess $\Gamma_2^{(1)}$, minimum surface tension at synergy $\gamma_{min}(c)$) • Typical measuring range γ_L: 1 ... 1000 mN/m
	• Determination of the static surface and interfacial tension of liquids • Determination of the cricital micelle concentration of surfactants (CMC) and of the synergy effect in surfactant mixtures	Wilhelmy plate method	• Measurement of the static interfacial or surface tension γ_L as a function of time $\gamma_L(t)$, temperature $\gamma_L(T)$ or the surfactant concentration $\gamma_L(c)$ to determine the CMC and other derived values (e.g. space requirement of a molecule on the surface A_M, surface excess $\Gamma_2^{(1)}$, minimum surface tension at synergy $\gamma_{min}(c)$) • In analogy to the Du Noüy ring method (advantage: no ring corrections required) • Typical measuring range γ_L: 1 ... 1000 mN/m

$$\Gamma_2^{(1)} = -\frac{1}{RT}\left(\frac{\partial\gamma}{\partial \ln c}\right)$$

Gibbs' equation of the relative adsorption on liquid surfaces (surface excess)

For the CMC determination – the SCAT 12 software
One of the standard tasks for the use of the DCAT 11 is the determination of characteristic parameters for pure surfactants and surfactant mixtures. Surfactants are compounds that in their molecular structure show hydrophilic as well as hydrophobic constituents. Due to partial hydrophobic properties, the surface-active molecules accumulate at the interface of water/air. With growing concentration, the degree of coverage of this boundary layer increases, until a saturation of surfactant molecules is reached. A further increase of the surfactant concentration leads to an increased formation of aggregated structures of surfactant molecules within the water. These structures, so-called micelles, generally have a spherical or rod shape. The minimum concentration at which the formation of micelles from surfactant monomeres starts is called the critical micelle formation concentration, shortly CMC. A continued increase of the surfactant concentration beyond the CMC generally does not result in a further significant reduction of the static surface tension of the surfactant solution.



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Therefore the CMC and the associated surface tension are the most important parameters of a surfactant or a surfactant mixture, the knowledge of which is a prerequisite for many technical applications. They are crucial not only for the economically, but increasingly also for the ecologically efficient use of surfactants. Whether in wetting agents, washing or cleaning solutions, shampoos, pharmaceutics, ink jet inks, paints and varnishes or in impregnating solutions for non-wovens and fabrics – modern skin-friendly and ecological surfactants are used for all these products.

Together with an optional dosing device, the SCAT 12 offers the convenience of performing the otherwise complicated manual CMC measurement in a very simple, program-controlled way. After the automatic measurement, the user can besides the CMC read the free energy of adsorption and the relative adsorption (surface excess) according to Gibbs as well as the space requirement of the molecule on the liquid surface as additional information.

Surface and interfacial tension measurement with systematics
Of course, the SCAT also permits the measurement of time- or temperature-dependent surface and interfacial tensions, for instance with the Du Noüy ring or the Wilhelmy plate according to DIN or ASTM. With the selectable automatic ring correction according to Zuidema and Waters or Mason/Huh, even ring measurements are extremely easy. Moreover, for repeated measurements important statistical data are either calculable or may be used as preset or abort criteria in the SCAT 12.

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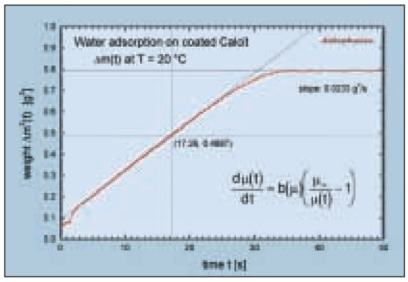

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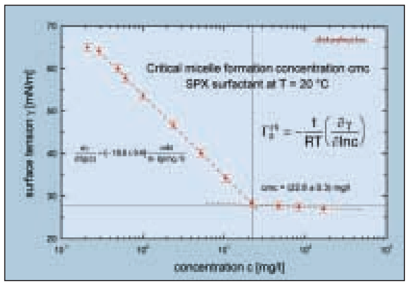

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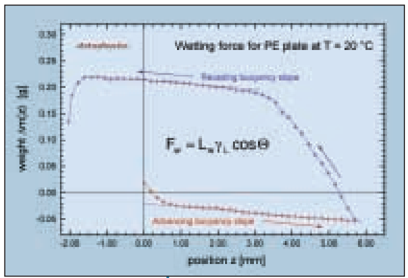

4
Adsorption on powder
5
CMC curve
6
Dynamic contact angle

How do you measure synergy effects?
If different types of surfactants are mixed together in solution, one often observes an additional, mostly advantageous reduction of the CMC. The measurement of this special effect due to intermolecular interaction is easily prepared methodically with the SCAT 12 software and afterwards represented in a graph. The minimum in the representation $\gamma_{cmc}(c_1)$ can then be determined numerically or graphically.

The DCAT instrument system

SCAT 11
Software for contact angle measurements on solids and powders

SCAT 12
Software for surface and interfacial tension measurements on liquids or surfactant solutions

Colour printer

Windows PC system

DCAT 11
Dynamic contact angle measuring instrument and tensiometer

HR 11
Absolute distance measuring system

DCAT 11HR
Dynamic contact angle measuring instrument and tensiometer with absolute distance measuring system

CP 50
Cover plate for sample vessel D 50 mm

GS 50
Sample vessel of borosilicate glass

GS 50 P
Sample vessel of PTFE

TV 50
Liquid temperature control device -10° ... 130°C sample vessel D 50 mm

DO 765
Precision dosing system Dosimat

LDU 11
Liquid dispenser unit

F 25-MV
Refrigerated bath/circulator -28° ... 200°C

CP 70
Cover plate for sample vessel D 70 mm

GS 70
Sample vessel of borosilicate glass

GS 70 P
Sample vessel of PTFE

TV 70
Liquid temperature control device -10° ... 130°C sample vessel D 70 mm

CP 100
Cover plate for sample vessel D 100 mm

GS 100
Sample vessel of borosilicate glass

GS 100 P
Sample vessel of PTFE

TV 100
Liquid temperature control device -10° ... 130°C sample vessel D 100 mm

PUR 11
Glass tube for powder samples

DIS 11
Density determination set

RG 10
Du Noüy ring to DIN 53914 for 0.2 ml sample volume

RG 11
Du Noüy ring to DIN 53914 standard

R-AT
Dressing tool for Du Noüy rings

FH 11/FH 12
Special sample holder for fibre bundles/ single fibres

FO 11
Special sample holder for film material

PT 10
Wilhelmy plate to DIN 53914 for 0.2 ml sample volume

PT 11
Wilhelmy plate to DIN 53914 standard

ADAPT 70
Receptacle adapter for GS 50 sample vessels in TV 70 temperature control devices

PSH 11
Special sample holder for plate-shaped solids

FP 11/FP 12
Filtering paper for PUR 11 and FH 11

Technical data DCAT 11 and DCAT 11HR at a glance*

Instrument system	DCAT 11/DCAT11 HR
Measuring range contact angle	• 0 ... 180° (at 90° there is no wetting force) • Resolution: ± 0.01 °
Measuring range surface and interfacial tension	• 1 ... 1000 mN/m • Resolution: ± 0.01 mN/m
Measuring range density	• 0.50 ... 2.50 g/cm³ • Resolution: ± 0.002 g/cm³
Weighing range	• 0.1 mg ... 210 g; • Resolution: ± 10 µg
Measuring value rate	• 30 weighing values/s; • For adsorption measurements: 50 weighing values/s
Programmable position range of sample stage	• 74 mm
Position resolution	• 1 µm/0.5 µm with DCAT 11HR optional
Displacement speed of sample stage	• 2 µm/s ... 1 mm/s (60 mm/min) in measuring mode • 400 mm/min rapid motion for adjusting mode
Sample size	• Max. weight: approx. 200 g • Max. diameter: approx. 80 mm • Min. fibre diameter: approx. 10 µm
Software	SCAT 11 • Force-based measurement of the dynamic contact angle of prismatic and cylindrical solids (e.g. plates, films, rods) as well as the wetted length according to the Wilhelmy method, adsorption measurement on powders and fibre bundles with determination of the average contact angle according to the modified and the extended Washburn method • Calculation of the surface free energy of solids and their components from measured contact angles with any number of test liquids, evaluation according to the methods of Fowkes (geometric mean), Wu (harmonic mean), Extended Fowkes (incl. hydrogen bonds), Zisman (critical surface tension), Owens-Wendt (dispersive & polar), van Oss & Good (acid-base theory, Neumann's Equation of State (EOS) • Determination of the density of liquids with silicon reference bodies
	SCAT 12 • Measurement of the static, time- and temperature-dependent surface and interfacial tensions of and/or between liquids according to the Du Noüy ring method (to DIN 53914 & ASTM-971), the Wilhelmy plate and the wire hoop method, tension and pressure on the interface • Fully automatic determination of the CMC and derived values (e.g. space requirement of a molecule on the surface, Gibbs' free energy of adsorption, surface excess, minimum surface tension in case of synergy effects and others) • Automatic ring corrections according to Zuidema/Waters and Mason/Huh • Ring tear-off test to determine the surface elasticity • Software control of the dosing devices DO 665, DO 765, and LDU 11
Temperature control range	• -10 ... +130° C
Temperature measurement and measuring range	• integrated temperature measurement and digital display • 2 x Pt 100 inputs for -60 ... +450° C (Pt 100 optional), 0.1 K resolution; accuracy: 1/3 DIN IEC 751 (± 0.03 %), class B
Holder for sample vessels	50, 70 und 100 mm; according to the temperature control devices used
Instrument dimensions (L x W x H)	305 x 230 x 490 mm
Weight	23 kg
Power supply	90 ... 264 VAC; 43 ... 60 Hz; 55 VA

*) The instruments are in compliance with European Standards regarding the EMV recommendation 89/336/EWG. Technical modifications reserved.

The system philosophy

Whether basic units, software, computers, system components, peripherals or accessories, we offer you exactly the right system configuration you require for your tasks.
Please contact us, we will be pleased to advise you and submit you an offer without obligation.

dataphysics

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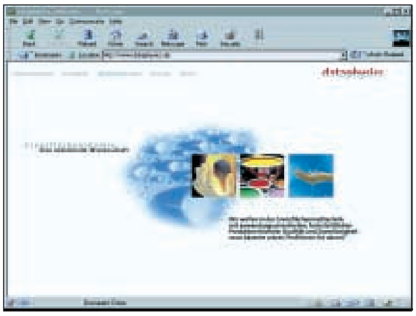

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