Surface Chemistry

An attractive science

dataphysics

Science

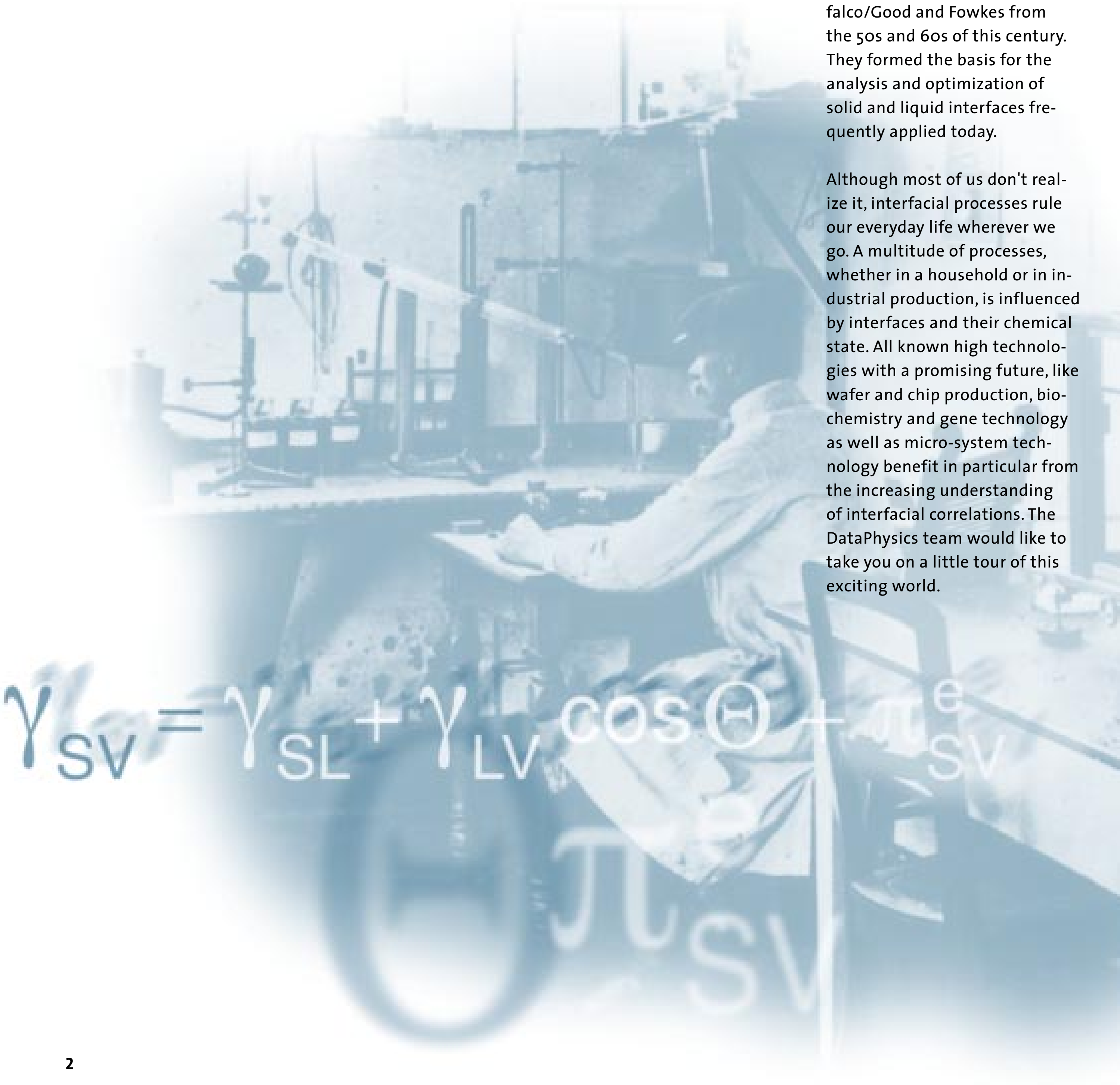
A short introduction to surface chemistry

A few words on the history and future of surface chemistry

For more than 400 years, important scientists and mathematicians like Leonardo da Vinci, Isaac Newton, Pierre Simon Laplace, Thomas Young, Siméon Denis Poisson, Josiah Willard Gibbs, Frederick M. Fowkes have done valuable pioneer work for the explanation of surface tension, capillarity, wetting and other interfacial problems.

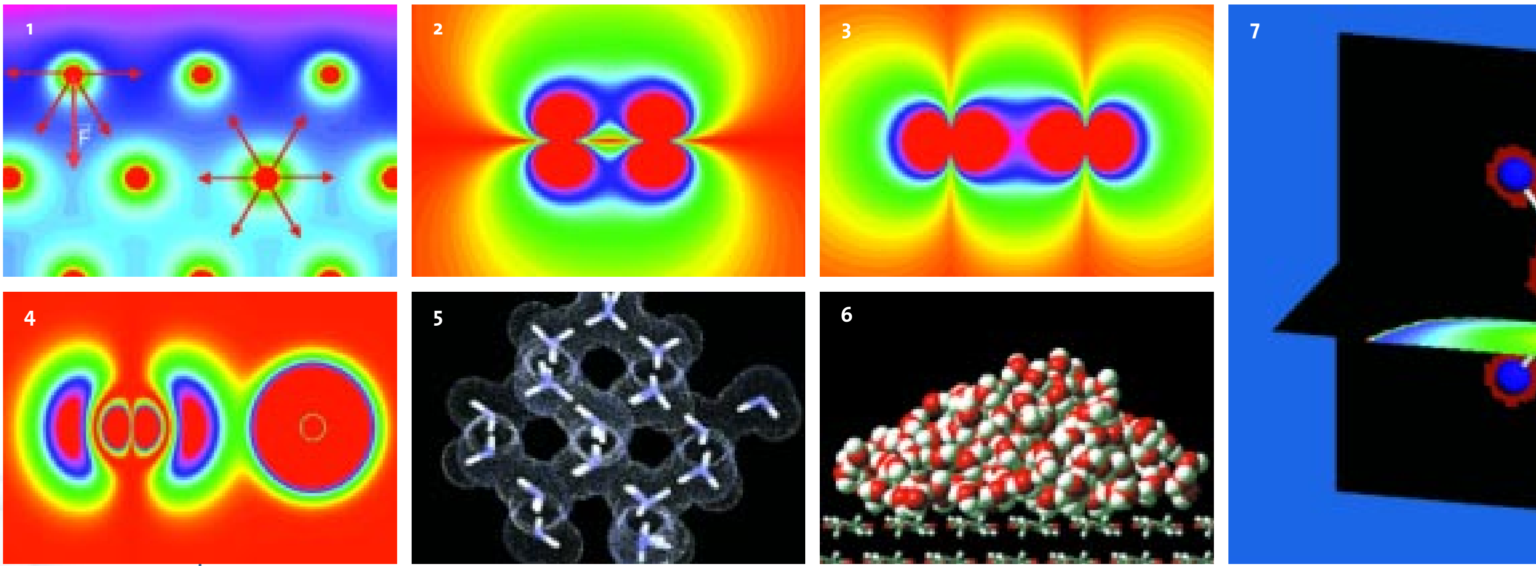
As a sector of physical chemistry, surface chemistry in connection with colloid chemistry established itself as an independent science about 70 years ago. Important milestones in modern theory and practice of wetting properties are the works of Girifalco/Good and Fowkes from the 50s and 60s of this century. They formed the basis for the analysis and optimization of solid and liquid interfaces frequently applied today.

Although most of us don't realize it, interfacial processes rule our everyday life wherever we go. A multitude of processes, whether in a household or in industrial production, is influenced by interfaces and their chemical state. All known high technologies with a promising future, like wafer and chip production, biochemistry and gene technology as well as micro-system technology benefit in particular from the increasing understanding of interfacial correlations. The DataPhysics team would like to take you on a little tour of this exciting world.



About interfacial interactions
When talking about the wetting behavior of liquids and solids; this is in fact surface chemistry. Apart from such properties as density or viscosity, liquids also have the property of surface tension, which specifies the amount of work necessary to create a piece of new surface. It is equivalent to the surface free energy of solids.

A series of inter- and intra-molecular interactions rules the surface phenomena, all of which have their origin in Coulomb's attraction or repulsion of differently or equally charged particles, electrons and nuclei. Phenomenologically, a distinction is made between static and induced dipole moments, which are named after their discoverers Keesom (1912), Debye (1920) and London (1930). The ratio of forces of the three interaction types in water for instance is 190:11:47.



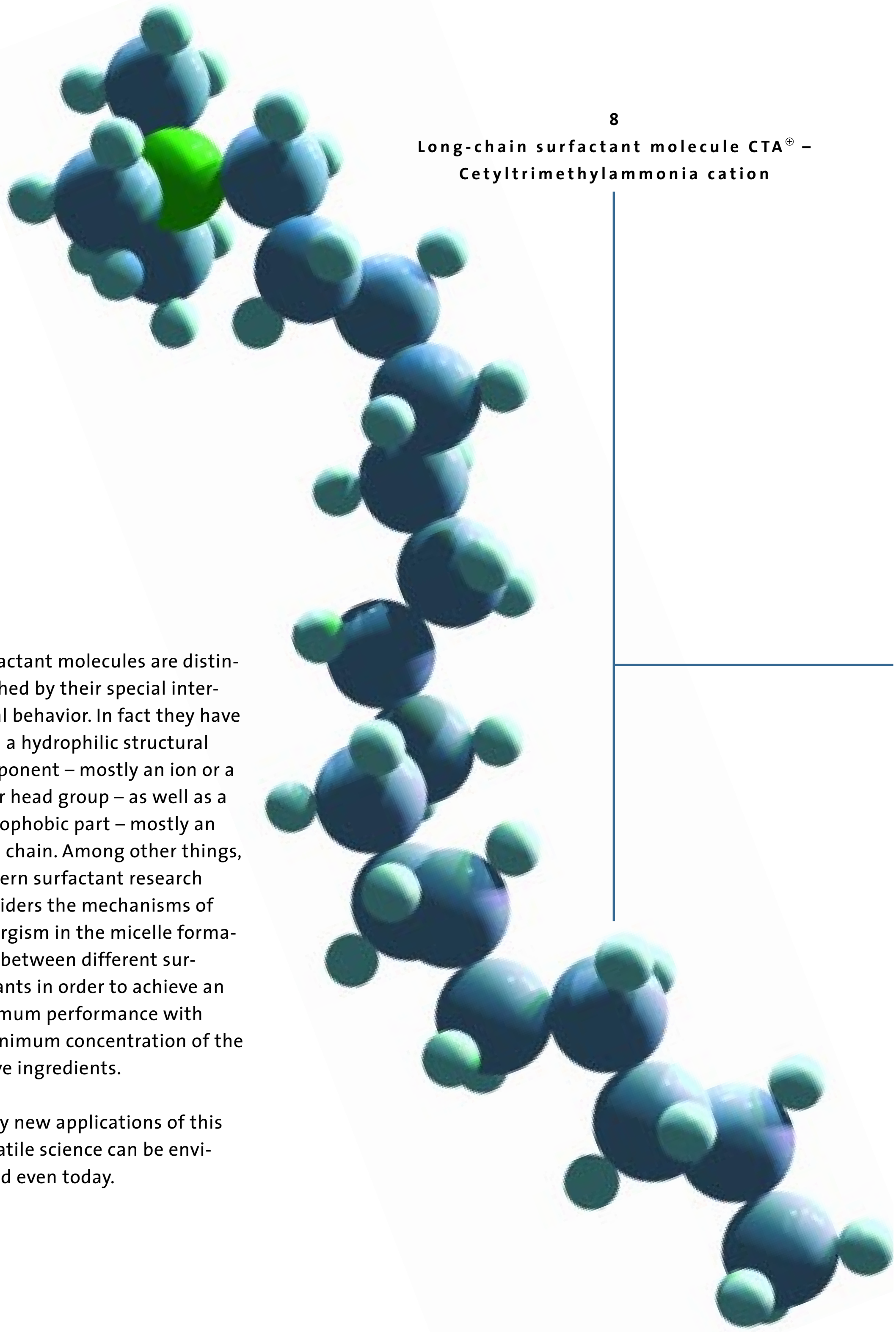
1
Molecular interactions on the liquid surface – Surface tension
2
Interaction of two dipoles (parallel position)
3
Interaction of two dipoles (head-on position)
4
p- and s-electron orbital gaining proximity
5
Cage structure of a water cluster
6
Calculation of a simulated contact angle – Water on a polymer (polyethylene terephtalate PET)

In summary they are known as »van der Waals interactions« and manifest themselves for example, in the deviation of gasses from ideal behavior.

Since the works of Latimer and Rodebush (1920) the additional possibilities of interaction in polar media such as water, alcohol or acetic acid are known.

Water molecules especially are exemplary representatives of the formation of so-called hydrogen bonds, whose presence shows in the known density anomaly of water (e.g. floating icebergs). The hydrogen bonds causing the formation of an orderly cage structure in water are the basis of all organic life. The bonding forces between the nucleic acids in the chromosome molecule DNS are naturally hydrogen bonds, too.

8
Long-chain surfactant molecule CTA$^{\oplus}$ – Cetyltrimethylammonia cation



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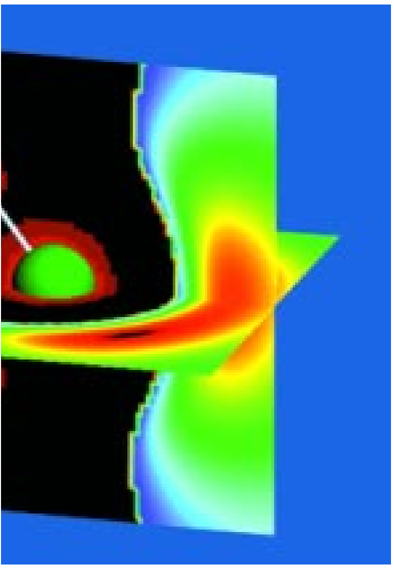
Electrostatic potential of a water molecule



Today, the Schrödinger equation as the physical basis of quantum chemistry forms the firm theoretical foundation of surface chemistry. Many numerical methods of approximation (e.g. ab initio, semi-empirical) have in recent years been continuously developed with the aim of understanding chemical bonding forces and courses of reaction with the help of the computer.

These efforts have also contributed to the description of the phenomenon of the contact or wetting angle of liquids on solids. Simulations on high-performance computers permit tracking the time evolution of an ensemble of water molecules on a crystalline polymer surface even in the picosecond range.

Surfactant molecules are distinguished by their special interfacial behavior. In fact they have both a hydrophilic structural component – mostly an ion or a polar head group – as well as a hydrophobic part – mostly an alkyl chain. Among other things, modern surfactant research considers the mechanisms of synergism in the micelle formation between different surfactants in order to achieve an optimum performance with a minimum concentration of the active ingredients.

Many new applications of this versatile science can be envisaged even today.

Photos:
1-4, 8 DataPhysics Instruments GmbH
5 University of Missouri-Rolla, Department of Physics, Rolla, MO USA
6 California Institute of Technology, Materials and Processing Simulation Center, Pasadena, CA USA
7 Michigan State University, Department of Chemistry and Center of Fundamental Materials Research, East Lansing, MI USA

What's the practical use of surface chemistry?

Without surface chemistry, the fields of material and process technology wouldn't exist today. Often, the knowledge of surface chemistry is of crucial importance for the development, production and processing of innumerable products.

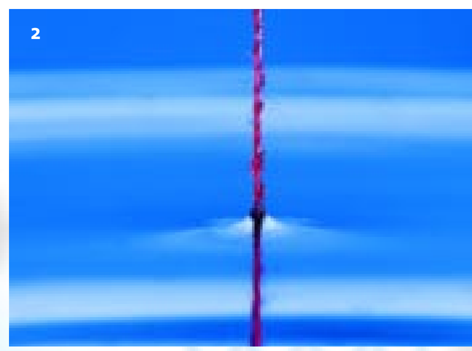
As an interdisciplinary science, surface chemistry deals with the specific interactions and properties of materials at phase boundaries and the physicochemical changes due to these interactions. Basic phenomena such as adhesion, capillarity, surface tension and wetting are explained in surface chemistry by means of thermodynamic, quantum-chemical and electrodynamic considerations. The relations between the existing forces and the occurring effects on the static and dynamic behavior of liquid, solid and gaseous phases at their spatial boundaries are modelled in the form of equations. In this way the properties of real interfaces can be described in the best possible approximation.

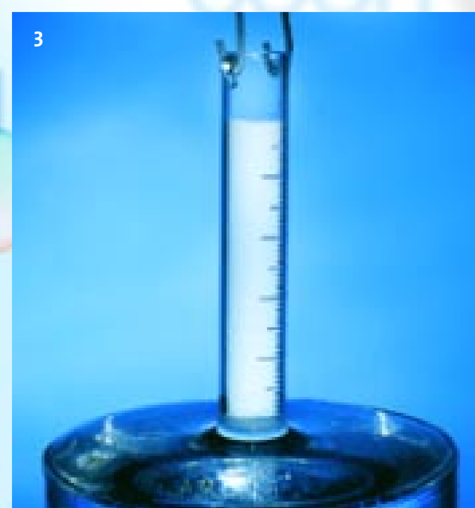
Modern surface chemistry is still a young science. Innovations are therefore of vital importance. We at DataPhysics are constantly searching for new solutions in surface chemistry. This is also useful when looking at the determination of interfacial properties. This determination of interfacial properties is however, an art of its own.

A short introduction to surface chemistry.
We have introduced you to a fascinating science. With the aid of surface chemistry, you will be able to better understand the surface properties of your products and to modify them efficiently. Use our know-how to do this.

Methods

About the art of determining surface properties





Measuring methods
Surface chemistry uses a variety of different measuring methods. The choice of measuring method depends on the application.

The following table shows an overview of tasks, measuring methods and test results.

Measuring devices and systems
When talking about measuring devices, a general distinction is made between contact angle measuring devices and tensiometers, and beyond that beween different measuring methods or test types (optical or power-based, ring, plate, bubble pressure, spinning drop and drop volume tensiometers).

Of the measuring geometries for force-based tensiometers, besides the classic Du Noüy ring of platinum iridium, the Wilhelmy plate, the Lenard frame and the vertical rod have all proved useful.

1
Sessile drop method

2
Single fibre contact angle method

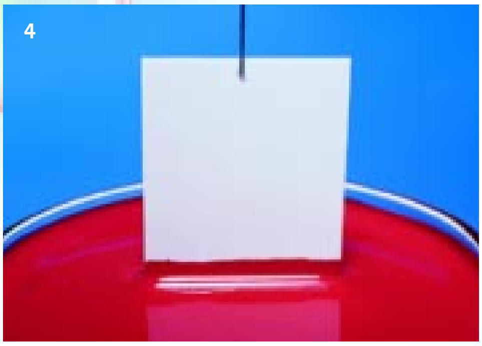
3
Powder contact angle method

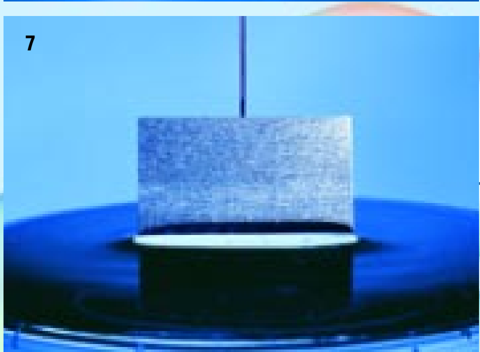
4
Dynamic Wilhelmy method

5
Pendant drop method

6
Spinning drop method

7
Wilhelmy plate method





Task

For solids

- Determination of the static and dynamic contact angle on solids
- Determination of the surface free energy of solids

- Determination of the contact angle of powders and fiber bundles
- Determination of the adsorption behavior of liquids on wettable materials

- Determination of the advancing and the receding angle of liquids on fibers
- Determination of the wetted circumference/diameter of fibers

- Determination of the advancing and the receding angle of prismatic and cylindric samples

For liquids

- Determination of the interfacial and surface tension of liquids

- Determination of the interfacial tension of liquids down to very low values
- Determination of the relaxation behavior of interfaces after speed steps and speed oscillations

- Determination of the static surface and interfacial tension of liquids
- Determination of the critical micelle concentration of surfactants (CMC)

- Determination of the static surface and interfacial tension of liquids
- Determination of the critical micelle concentration of surfactants (CMC)

- Determination of the static and dynamic surface and interfacial tension, especially suited for highly viscous liquids (e.g. molten polymers) with simultaneous determination of the contact angle on fibers

- Determination of the dynamic surface tension of liquids

- Determination of the dynamic interfacial tension of liquids

Measuring method	Test results: interface-specific parameters and measuring ranges of typical instrument systems
Sessile drop method and Tilting plate method	• Measurement of the static contact angle Θ^{stat} of sessile drops of liquid on a surface as a function of time $\Theta^{stat}(t)$ or temperature $\Theta^{stat}(T)$ • Measurement of the dynamic contact angle Θ^{dyn} als as a function of the dosing rate $\dot{V}$: as advancing angle $\Theta_A(\dot{V})$ and as receding angle $\Theta_R(\dot{V})$ • Measurement of the difference between advancing angle and receding angle (contact angle hysteresis) $\Delta\Theta_{AR}(\dot{V})$ by metered addition or removal of liquid • Measurement of the contact angle $\Theta_A(\alpha)$ or $\Theta_R(\alpha)$ until the rolling off of the drop on a plate inclined with the angle α (tilting plate method) • Calculation of the critical surface tension γ_S^C and of the surface free energy γ_S: determination of the dispersion γ_S^d as well as the non-dispersion γ_S^{nd} parts (e.g. polar parts γ_S^p, acid/base parts $\gamma_S^{\oplus}/\gamma_S^{\ominus}$, hydrogen bonding parts γ_S^H) from contact angle measurements with various test liquids • Typical measuring ranges Θ/γ_S: 0 ... 180°/0,1 mN/m ... 1000 mN/m
Modified Washburn method	• Measurement of the dynamic contact angle $\Theta_A(t)$ as a function of time t • Measurement of the adsorption speed of a liquid quantity m_L to the sample m_S as a function of time $\Delta m_L(t)/m_S$ • Typical measuring range Θ: 0 ... 80°
Single fiber 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 fiber into or out of a test liquid: as advancing angle $\Theta_A(v)$ and 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 L or of the average fiber diameter D by means of a completely wetting liquid ($\Theta \approx 0°$) • Calculation of the critical surface tension γ_S^C as well as of the surface free energy γ_S possible from $\Theta_A(v)$ like with the sessile drop method • Typical measuring range γ_S: 0,1 ... 1000 mN/m
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 $\Theta_A(v)$ and as receding angle $\Theta_R(v)$ • Measurement of the difference between advancing angle and receding angle (contact angle hysteresis) $\Delta\Theta_{AR}(v)$ • Calculation of the critical surface tension γ_S^C as well as of the surface free energy γ_S possible from $\Theta_A(v)$ like with the sessile drop method • Typical measuring range γ_S: 0,1 ... 1000 mN/m
Pendant drop method	• Measurement of the static interfacial or surface tension as a function of time $\gamma_L(t)$ or of temperature $\gamma_L(T)$ • Measurement of the adsorption/diffusion coefficients of surfactant molecules in vibrating/relaxing drops • Typical measuring range γ_L: 0,05 ... 1000 mN/m
Spinning drop method	• Measurement of the interfacial tension as a function of time $\gamma_L(t)$ or of temperature $\gamma_L(T)$ • Determination of the solubility and diffusion behavior of adjacent liquid phases • Measurement of the relaxation properties on interfaces (surface elasticity) after speed steps $\Delta\omega$ or speed oscillations $\Delta\omega_0\cos(\Omega t)$: $\gamma_L(t, \Delta\omega)$ • Typical measuring range γ_L: 10^{-5} ... 20 mN/m (with video image evaluation)
Du Noüy ring method	• Measurement of the static interfacial or surface tension γ_L as a function of time $\gamma_L(t)$, of temperature $\gamma_L(T)$ or of the surfactant concentration $\gamma_L(c)$ to determine the CMC and other derived values • Typical measuring range γ_L: 1 ... 1000 mN/m
Wilhelmy plate method	• Measurement of the static interfacial or surface tension γ_L as a function of time $\gamma_L(t)$, of temperature $\gamma_L(T)$ or of the surfactant concentration $\gamma_L(c)$ to determine the CMC and other derived values • In analogy to the Du Noüy ring method (advantage: no measuring body corrections required) • Typical measuring range γ_L: 1 ... 1000 mN/m
Optical Wilhelmy rod/fiber method (special case of the Wilhelmy method with video evaluation)	• Measurement of the static contact angle Θ^{stat} • Measurement of the dynamic contact angle Θ^{dyn} as a function of the immersion speed v of the fiber/rod into or out of a sample liquid: as advancing angle $\Theta_A(v)$ and as receding angle $\Theta_R(v)$ with simultaneous measurement of the surface tension of the test liquid γ_L (possible with video evaluation) • Measurement of the difference between advancing angle and receding angle (contact angle hysteresis) $\Theta_{AR}(v)$ • Calculation of the critical surface tension γ_S^C as well as of the surface free energy γ_S from $\Theta_A(v)$ possible like with the sessile drop method • Typical measuring range γ_L/Θ: 10 ... 1000 mN/m / 10 ... 80°
Maximum bubble pressure method	• Measurement of the dynamic surface tension γ_L^{dyn} as a function of surface age $\gamma_L^{dyn}(t_A)$ or bubble frequency, $\gamma_L^{dyn}(f_b)$ • Measurement of the dynamic surface tension as a function of temperature $\gamma_L^{dyn}(T, t_A)$ or of concentration $\gamma_L^{dyn}(c, t_A)$ • Typical measuring range γ_L: 10 ... 100 mN/m • Typical surface age range t_A: 1 ms ... 60 s • Typical bubble frequency range t_{bubble}: 0,01 ... 50 Hz
Drop volume method (also known as drop weight method)	• Measurement of the static interface or surface tension γ_L^{dyn} as a function of dosing rate $\gamma_L^{dyn}(\dot{V})$ or of drop age $\gamma_L^{dyn}(t_A)$ • Measurement of the dynamic interfacial tension as a function of temperature $\gamma_L^{dyn}(T,t_A)$ or of concentration $\gamma_L^{dyn}(c,t_A)$ • Typical measuring range γ_L: 0,1 ... 100 mN/m • Typical surface age range t_A: 0,3 ... 2000 s

Today tensiometers of the modern type do not only serve for determining the static surface or interfacial tension, but are increasingly used for determining the corresponding dynamic quantities, e.g. by measuring the maximum bubble pressure or the drop volume method. For measuring the contact angle, in addition to manual visual observation with an angle measuring eyepiece efficient video-supported methods gain acceptance.

State-of-the-art contact angle measuring systems use high-resolution optical sensors and moreover they have automatic control and evaluation systems for sample stages and dosing devices. They permit the determination of the static or dynamic contact angle including the contact angle hysteresis and additionally the measuring of the surface or interfacial tension from the drop or bubble shape. The increasing tendency of combining previously separated technologies in instrument systems provides new benefits for the user.

Approximative methods and manual contour presets on the video picture to measure the contact angle or the interfacial tension are making room for highly developed contour searching algorithms and the exact solution of the Young-Laplace differential equation which underlies the phenomena.

Optical reference plates with standard contours of droplets and liquid lamellae – from controlled high-precision manufacturing – give every user the security that measuring values are determined precisely and that the traceability to national standards is ensured.

8

9

10

8
Du Noüy ring method
9
Bubble pressure method
10
Drop volume method

About the art of determining surface properties

The people in our company will provide you with just what you need in theory and practice. Come and see for yourself.

Applications

We model our work on our customers' wishes.

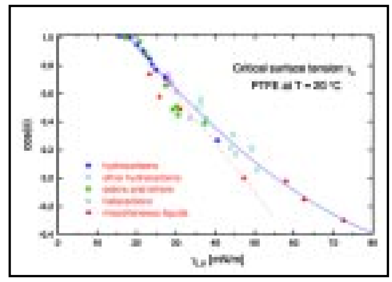
For many industries, the findings of surface chemistry are of great application importance. The materials of the future are inconceivable without the knowledge of interfacial functioning and mechanisms. Measurable and evaluative quantities and properties like contact angle, surface free energy, interfacial tension and adsorption permit the assessment of the wetting and immersion behavior of liquids and solids. The consistent application of the measuring methods presented here permits a specific development of products which are perfectly geared to the desired chemical and physical properties.

Benefitting from this are the paint, varnish and ink industries, the semi-conductor and display industries, cosmetic, pharmaceutical and dental industry as well as biotechnology and the manufacturers of textiles, plastics and adhesives, films and optical products.

Paint and varnish
For the production and processing of paints and varnishes, surfactants play an important role as varnish additives. As wetting agents they help disperse dry color pigments, they are used as defoamers and deaerators; as a substrate wetting agent they reduce the surface tension of a varnish system and in this way improve the wetting behavior of critical material surfaces. As slip additive they lower the sliding friction coefficient of the varnish surface and make it more resistant against scratches and soiling. And not least, varnish additives improving the levelling properties are responsible for the visual quality of the varnish surface.

Cosmetics
The cosmetics industry depends on the use of surfactant substances in nearly all products, for instance in the production of soaps, toothpastes, hair shampoos and dyes, washing and cleaning agents tolerated by the skin as well as additives for bubble baths. In hair cosmetics, the anti-static and softening properties of special surfactants are used to make combing easier, to reduce electrostatic charging and to enhance the shine of the hair.

1



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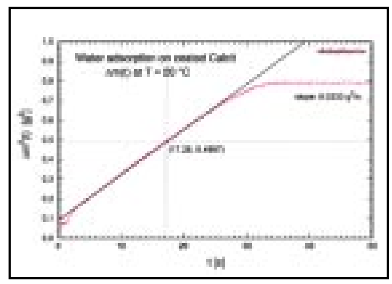

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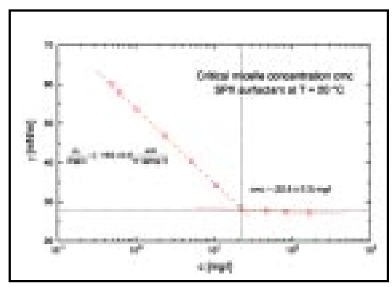
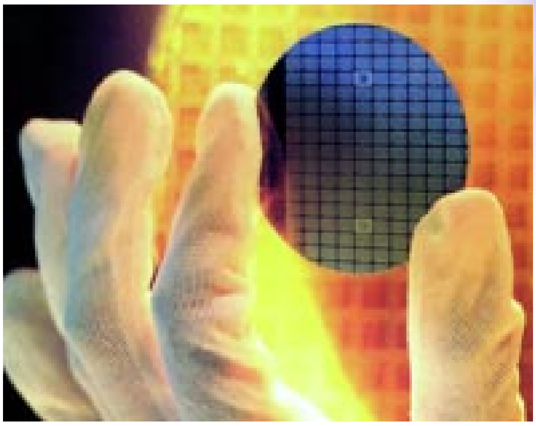


Microprocessors and monolayers
The basis for the production of microprocessors is a round, thin silicon platelet, the so-called wafer. To its surface, by means of photo-lithographic processes, the semi-conductor structure is applied in fractions of a micrometer through many stages of cleaning and doting. The manufacture of such extreme microstructures demands the precise setting and control of the surface-chemical properties of the wafer surface and the process chemicals.



1
Measurement of the critical surface tension of a fluorine polymer (PTFE)

2
Determination of the contact angle of a pigment powder with the modified Washburn method

3
γ-lg(c) isotherm of a surfactant with determination of the CMC

Completely new possibilities for the production of materials and the design of production processes are for instance offered by self-assembling monolayers, so-called SAMs. The specific design of such monomolecular layers permits controlled growth of living cells, to set material properties like wetting, adhesion and friction and to build microstructures with specific physical properties.

We model our work on our customers' wishes.
The progress in our products is the result of the consistent implementation of your wishes. You determine our action.

Products

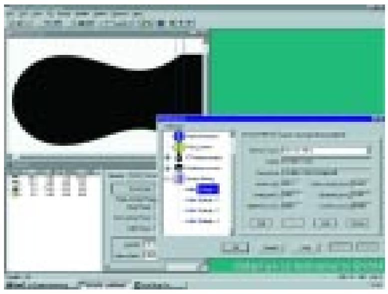
Superior performance for perfect results

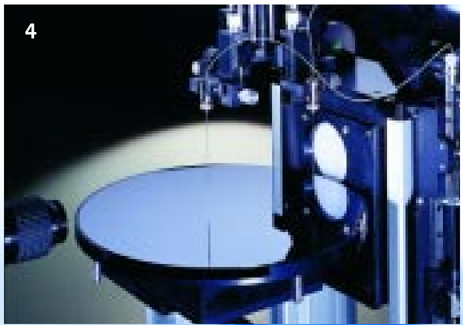
At DataPhysics, natural scientists and engineers work in close co-operation with customers, scientific institutes and research institutions on new products for measuring surface-chemical properties. It is their aim to give a fresh impetus to the progress of surface chemistry by their innovative power and to develop superior products for critical customers.

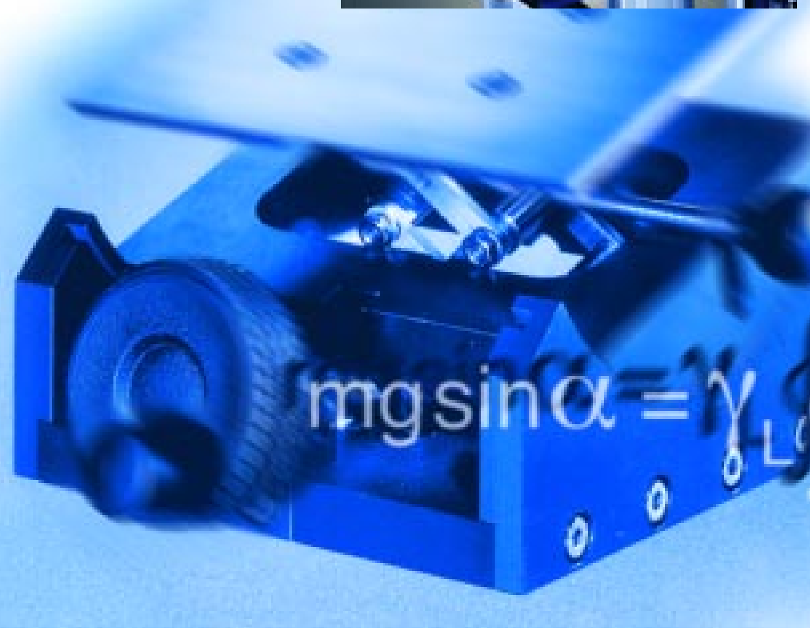
DataPhysics products are the latest state-of-the-art. They impress by their functional design, and with their solid, precise mechanics designed for a long service-life, they guarantee a maximum measuring accuracy over many years of operation. Intelligent micro-electronics and convenient software such as 32-bit-application under Windows 9x and Windows NT ensure a comfortable and efficient operation.

1

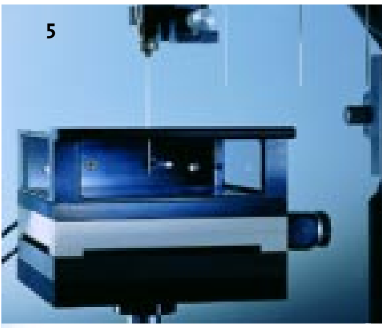
2







1
Contact angle measurement with the SCA software evaluation of the surface free energy according to Fowkes
2
Interfacial tension measurement according to the Pendant Drop method – Parameterizing the dosing systems
3
Video-supported contact angle measuring instrument OCA 20



4
Wafer stage WT 200M
5
Liquid temperature control TFC 100
6
CCD camera of the OCA 20

The video-supported contact angle measuring instrument OCA 20 shown here as an example of the DataPhysics instrument range is part of the comprehensive modular »OCA construction kit«. The user benefits from a combination of optical and electronic components, software modules and technical solutions for many applications.

The OCA 20 is equipped with a high-resolution CCD camera and a six-fold power zoom objective lens with integrated fine focus. The particularly high-contrast image quality of the objective together with the homogeneous background lighting will impress every user – and not only for contact angle measurement.

Since the detection of the exact temperature is important for all thermodynamic values, DataPhysics has integrated temperature measurement in the range from -10 to +400°C in all OCA systems. Adjustable in three degrees of freedom, the sample stage enables easy adjustment of the measuring positions of the sample body. Additionally, the dosing needles for the test liquids can be individually adjusted vertically and horizontally to the optical axis.

Moreover, temperature controls and special sample stages, for instance for wafers, foils, textiles and printing cylinders are available from the »OCA construction kit«. With the extended model OCA 20L, DataPhysics offers solutions even for non-standard sample sizes. The micro-controller module in the OCA 20 ensures movement in the liquid handling as well as during measurement. One of the four possible motor-driven dosing modules can be connected to the OCA 20 and the control software quickly and easily. With this, both the static and dynamic contact angles as well as the surface and interfacial tensions can be calculated from the contours of suspended drops or liquid lamellae.

Software equipped with many graphic elements and designed for intuitive operation assists you in defining the dosing system parameters, presetting a test procedure, recording the measured values and evaluating and analyzing them. DataPhysics has specialized in exact and reliable methods of drop contour evaluation with statistical error analysis.

In order to give you a head start, our mathematicians and engineers have contributed a lot of experience and creativity to the development of the software packages for the SCA series.

Superior performance for perfect results.
With user-oriented, progressive products of superior quality and reliability, we want to lead the way to the future in interface measuring technology. This will in turn benefit you.

Technology

Intelligent solutions for a measuring technology that points the way ahead

On the threshold of the next millennium, new ideas and technologies are needed to develop modern instrument systems. Measuring methods that have been known for years gain in importance beyond mere laboratory use to process monitoring and control.

Whether for high speed imaging in optical contact angle measuring instruments, for high-precision weighing systems in powderbased contact angle measuring instruments or for optical contact angle measuring heads for process use with robot systems – the specialists at DataPhysics are working creatively on solutions that point the way ahead and which will revolutionize interfacial measuring technology.

Modular electronics – A multi-processor system manages complex tasks

Today, microprocessors are used even in the smallest components to manage complex tasks such as dosing, precise moving and positioning or for measurement and control.

In DataPhysics system components like for instance dosing modules, temperature controls, wafer or tilting stages, objective lens adjustments or positioning drives, intelligent microelectronics ensure the desired functionality and precision.

Via a flexible and fast bus system the master controller monitors the communication between the individual system components and of course ensures correct timing. The modular DataPhysics electronics can always be extended. We have taken the »Plug and Play« principle seriously.

High speed imaging helps to understand interface-chemical phenomena

Adsorption processes on highly adsorbent papers or porous solid surfaces that happen within a few tenths of a second, are too fast for standard video systems. New and especially quick solutions are needed. DataPhysics engineers have succeeded in recording interface-chemical phenomena with a resolution of 512 x 512 image pixel at a speed of up to 400 full frames per second.

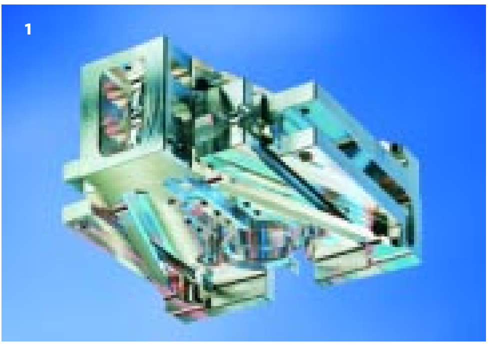
1
»Monolith« precision weighing module for weight measurement according to the modified Washburn method (with kind permission of Sartorius AG, Göttingen, Germany)

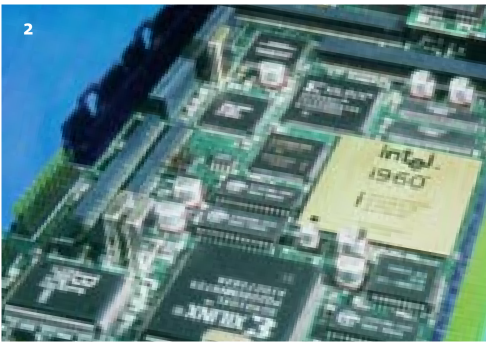
2
High-speed frame grabber for an image processing rate of up to 400 frames per second

3
Electronic syringe unit ES

Intelligent solutions for a measuring technology that points the way ahead

We develop measuring instruments and systems for research, product development and quality monitoring, for laboratory and process applications.



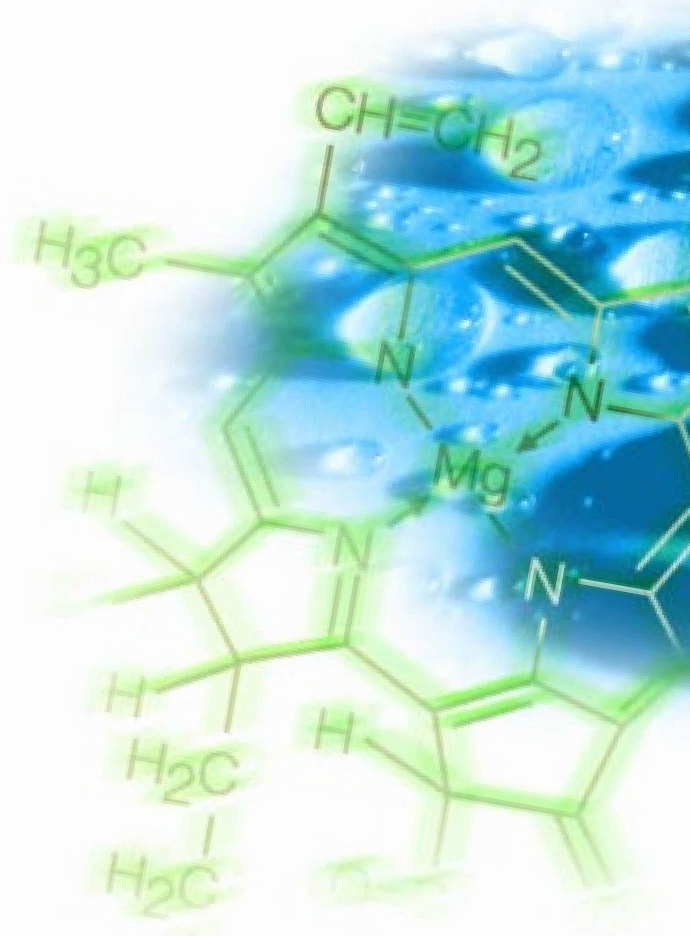


From the complete drop image, with the help of the world's fastest signal processors every 2.5 milliseconds the contact angle is determined in real time – without any memory limitation of the electronic system.

As for precision there are no restrictions in the measurement of adsorption dynamics with our high-speed contact angle measuring systems of the OCAH series. With DataPhysics instrument systems you possess state-of-the-art technology.

Service

Where for others, interfaces remain a phenomenon, we help to understand them



Our qualified engineers and natural scientists provide you with the services that you need to get the maximum benefit from your investment:

Training program

• Workshops, where you are familiarized with the fundamental theories of surface chemistry and have the opportunity to apply the things you learned in practice

• Application days, where you receive application-specific information about the use of the measuring instruments and the interpretation of the measuring results and the opportunity to discuss your experiences with other users

• Commissioning and customer training by our instrument and application specialists, who will familiarize you with the operation of the instrument and the evaluation of the measuring results on the job

• Instrument training for the users in your company or in our application laboratory; exchange of experience and assistance in the translation of practice-relevant problems into suitable application programs

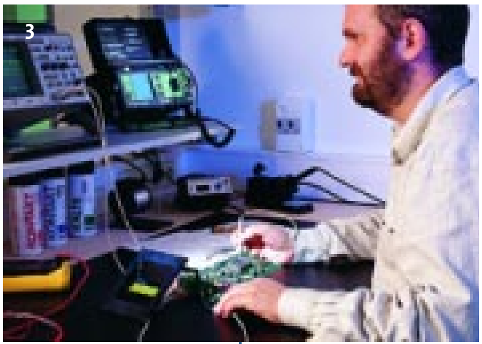
Application-technical support

• Support in the solution of difficult application-technical problems, especially in the determination of suitable test conditions

• Application reports on successfully solved measuring tasks and the resulting benefit for the user

Service
We give a 2 year warranty on all instruments. For the rare cases where an instrument shows a defect, you may rest assured that this will be repaired quickly. Service and repair contracts extend the warranty period and ensure the constant quality of your measuring instruments and devices over many years of operation. Our product specialists on the hot-line help with the quick solving of problems that may occur in the use of your measuring instrument. Very often, a telephone call means that no site visit is necessary.

Accessories and incidentals
The timely supply of accessories and incidentals is essential for the daily operation of your instruments. We keep accessories and incidentals in stock and deliver at short notice and at reasonable prices.



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Interesting facts

The result of creative surface chemistry
for all those who want to know more

Literature on the subject

The wealth of experience and knowledge about surface chemistry can be found in the following selection of current standard literature:

E. Matijevic (Ed.): **Surface and Colloid Science,** Vol. 1-15, Wiley Interscience & Plenum Publ. Co., 1969-1993, ISBN (Vol. 1) 0-4715-7630-1 ... ISBN (Vol. 15) 0-3064-4150-0, ISSN 0081-9573

K.S. Birdi (Ed.): **Handbook of Surface and Colloid Chemistry,** CRC Press, Boca Raton, New York, 1997, ISBN 0-8493-945-7

A.W. Adamson, A.P. Gast: **Physical Chemistry of Surfaces,** 6th ed., John Wiley & Sons, New York, 1997, ISBN 0-471-14873-3

D.J. Shaw: **Introduction to Colloid and Surface Chemistry,** 3rd ed., Butterworths, London 1980, ISBN 0-408-71049-7

M.J. Schwuger: **Lehrbuch der Grenzflächenchemie,** Georg Thieme Verlag, Stuttgart, New York, 1996, ISBN 3-13-137501-9

G. Brezesinski, H.-J. Mögel: **Grenzflächen und Kolloide,** Spektrum Verlag, Heidelberg, Berlin, Oxford, 1993, ISBN 3-86025-016-7

H.-D. Dörfler: **Grenzflächen- und Kolloidchemie,** VCH Verlag, Weinheim, 1994, ISBN 3-527-29072-9

P.C. Hiemenz, R. Rajagopalan: **Principles of Colloid and Surface Chemistry,** 3rd ed., Marcel Dekker, New York, 1997, ISBN 0-8247-9397-8

D. Myers: **Surfaces, Interfaces, and Colloids,** John Wiley, New York, 1990, ISBN 0-471-18786-0

M.J. Jaycock, G.D. Parfitt: **Chemistry of Interfaces,** Ellis Horwood, Chichester, 1981, ISBN 0-470-27013-6

F. MacRitchie: **Chemistry at Interfaces,** Academic Press, San Diego, 1990, ISBN 0-12-464785-5

J.N. Israelachvili: **Intermolecular and Surface Forces,** 2nd ed., Academic Press, New York, 1991, ISBN 0-1237-5181-0

C.J. van Oss: **Interfacial Forces in Aqueous Media,** Marcel Dekker, New York, 1994, ISBN 0-8274-9168-1

J.S. Rowlinson, B. Widom: **Molecular Theory of Capillarity,** Clarendon Press, Oxford, 1989, ISBN 0-19-855642-X

R. Finn: **Equilibrium Capillary Surfaces,** Springer Verlag, New York, 1986, ISBN 0-387-96174-7

A.I. Rusanov, F.C. Goodrich (Eds.): **The Modern Theory of Capillarity,** Akademie Verlag, Berlin 1981

S. Hartland, R.W. Hartley: **Axissymmetric Fluid-Liquid Interfaces,** Elsevier, Amsterdam, 1976, ISBN 0-4444-1396-0

K.L. Mittal (Ed.): **Contact Angle, Wettability and Adhesion,** VSP, Utrecht, 1993, ISBN 90-6764-157-X

J.C. Berg: **Wettability,** Marcel Dekker, New York, 1993, ISBN 0-8274-9046-0

J.F. Padday (Ed.): **Wetting, Spreading and Adhesion,** Academic Press, New York, 1978, ISBN 0-1254-4350-1

M.E. Schrader, G.Loeb (Eds.): **Modern Approaches to Wettability,** Plenum Press, New York, 1992, ISBN 0-3064-3985-9

A.I. Rusanov, V.A. Prokhorov: **Interfacial Tensiometry,** Elsevier, Amsterdam, 1996, ISBN 0-444-82128-7

K.L. Mittal (Ed.): **Adsorption at Interfaces,** 5th ed., Wiley Interscience, New York, 1990, ISBN 0-8412-0249-4

S.S. Dukhin, G. Kretschmar, R. Miller: **Dynamics of Adsorption at Liquid Interfaces,** Elsevier, Amsterdam 1995, ISBN 0-444-88117-4

C.A. Miller, P. Neogi: **Interfacial Phenomena,** Marcel Dekker, New York, 1985, ISBN 0-8274-7490-6

C. Isenberg: **The Science of Soap Films and Soap Bubbles,** Dover Publ., New York, 1992, ISBN 0-486-26960-4

D. Möbius, R. Miller: **Drops and Bubbles in Interfacial Research,** Elsevier, Amsterdam, 1998, ISBN 0-444-82894-X

N.R. Morrow (Ed.): **Interfacial Phenomena in Petroleum Recovery,** Marcel Dekker, New York, 1990, ISBN 0-8274-8385-9

C.A. Croxton: **Fluid Interfacial Phenomena,** John Wiley, Chichester, 1986, ISBN 0-4719-0757-X

D.K. Chattoraj, K.S. Birdi: **Adsorption and the Gibbs Surface Excess,** Plenum Press, New York, 1984, ISBN 0-306-41334-5

N.M. van Os, J.R. Haak, L.A.M. Rupert: **Physico-chemical Properties of Selected Anionic, Cationic and Nonionic Surfactants,** Elsevier, Amsterdam, 1993, ISBN 0-444-89691-0

M.J. Rosen: **Surfactants and Interfacial Phenomena,** 2nd ed., John Wiley, New York, 1989, ISBN 0-471-83651-6

K.L. Mittal (Eds.): **Surfactants in Solution,** Marcel Dekker, New York, 1996, ISBN 0-8247-9792-2

J.D. Andrade (Ed.): **Surface and Interfacial Aspects of Biomedical Polymers,** Plenum Press, New York, 1985

I. Noda, D.N. Rubingh: **Polymer Blends, Solutions, and Interfaces,** Elsevier, Amsterdam, 1992, ISBN 0-4448-9397-0

S. Wu: **Polymer Interface and Adhesion,** Marcel Dekker, New York, 1982, ISBN 0-8247-1533-0

K.L. Mittal, H.R. Anderson (Eds.): **Acid-Base Interactions: Relevance to Adhesion Science and Technology,** VSP, Utrecht 1991, ISBN 90-6764-135-9

L.H. Lee (Ed.): **Fundamentals of Adhesion,** Plenum Press, New York, 1990, ISBN 0-3064-3470-9

W.C. Wake: **Adhesion and Formulation of Adhesives,** Elsevier, New York, 1982, ISBN 0-8533-4134-6

I. Skeist: **Handbook of Adhesives,** 3rd ed., Chapman & Hall, New York 1990, ISBN 0-412-09681-1

A.J. Kinloch: **Adhesion and Adhesives,** Chapman & Hall, London, 1987, ISBN 0-412-27440-X

A.F.M. Barton: **Handbook of Solubility Parameters and Other Cohesion Parameters,** CRC Press, Boca Raton, New York, 1991, ISBN 0-8493-0176-9

H.J. Jacobasch: **Oberflächenchemie faserbildender Polymere,** Akademie Verlag, Berlin, 1984

I.B. Ivanov: **Thin Liquid Films,** Marcel Dekker, New York, Basel, 1988, ISBN 0-8247-7763-8

D.A. Edwards, H. Brenner, D.T. Wasan: **Interfacial Transport Processes and Rheology,** Butterworths-Heinemann, Boston, 1991, ISBN 0-7506-9185-9

A.W. Neumann, J.K. Spelt: **Applied Surface Thermodynamics,** Marcel Dekker, New York, 1996, ISBN 0-8274-9096-0

S.A. Safran: **Statistical Thermodynamics of Surfaces, Interfaces, and Membranes,** Addison-Wesley, Reading MA, 1994, ISBN 0-201-62633-0

S. Chen, R. Rajagopalan: **Statistical Thermodynamics of Micelles and Microemulsions,** Springer Verlag, New York, 1990, ISBN 3-5409-7106-8

P. Becher: **Dictionary of Colloid and Surface Science,** Marcel Dekker, New York, 1989, ISBN 0-8274-8326-3

L.E. Schramm: **The language of colloid and interface science: A dictionary of terms,** ACS, Washington D.C., 1993, ISBN 08412-2710-1

An extended and regularly updated list of literature is available by email, mentioning the keyword »literature list«, to: info@dataphysics.de.

Special articles and application reports

DataPhysics keeps special articles, application reports and bibliographies available for you. Speak to our experts, they will give you the essential sources on the following subjects:

- Static and dynamic surface and interfacial tension measurement
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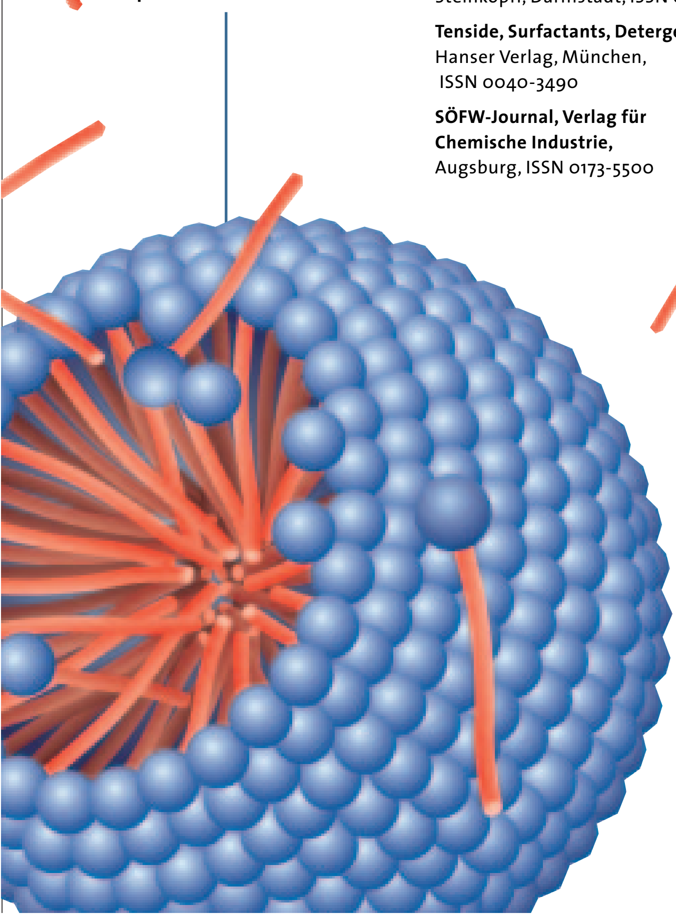
- Adsorption/desorption of surfactant materials on solids and liquid surfaces
- Measurement of the powder contact angle
- Surface tension measurement on molten polymers and liquid crystals
- Surfactants: working mechanisms, micelle formation, critical micelle concentration, synergism Gluing and bonding to solid surfaces
- Properties of printing inks and the printing of paper and plastic materials
- Measurement of the surface free energies and the wetting of fibers

Structure of a spherical micelle



The following specialist journals are published with important contents on surface chemistry (selection):

Journal of Colloid and Interface Science, Academic Press, New York, ISSN 0021-9797

Langmuir, American Chemical Society, Washington D.C., ISSN 0743-7463

Colloids and Surfaces A, Elsevier, Amsterdam, ISSN 0927-7757

Colloids and Surfaces B, Elsevier, Amsterdam, ISSN 0927-7765

Advances in Colloid and Interface Science, Elsevier, Amsterdam, ISSN 0001-8686

Journal of Adhesion Science Technology, VNU Science Press, ISSN 0169-4243

International Journal of Adhesion and Adhesives, Elsevier, Amsterdam, ISSN 0143-7496

Journal of Dispersion Science Technology, Marcel Dekker, New York, ISSN 0193-2691

Colloid Journal (engl. transl. of Kolloid-nyi Zhurnal) Maik Nauka, Moscow/ Interperiodica Publ., ISSN 0190-4337

Powder Technology, Elsevier, Amsterdam, ISSN 0032-5910

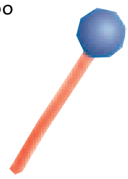
SIA Surface and Interface Analysis, Wiley, Chichester, ISSN 0142-2421

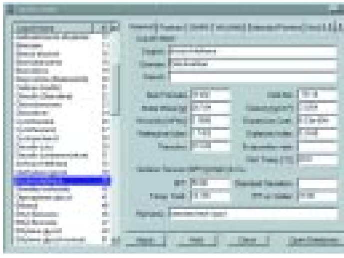
Trends in Colloid and Interface Science, Verlag Th. Steinkopff, Darmstadt, ISSN 0340-255X

Colloid & Polymer Science, Verlag Th. Steinkopff, Darmstadt, ISSN 0303-402X

Tenside, Surfactants, Detergents, Hanser Verlag, München, ISSN 0040-3490

SÖFW-Journal, Verlag für Chemische Industrie, Augsburg, ISSN 0173-5500





The DataPhysics liquid and solid data base for surface chemistry

DataPhysics not only informs about suitable methods, but also about material parameters already measured. Therefore make use of the opportunity, after a simple Internet registration (**http://www.dataphysics.de/surface-database/**) to use the following material parameters (all literature references stated):

1. Physico-chemical data

of interfacial test liquids (presently more than 140 entries): Name, total formula, molecular weight, surface tension and its temperature coefficient, polar and dispersion forces contributions, hydrogen bonding forces contributions, acid-base contributions, density, viscosity, die lectric constant, index of refraction, interfacial tension vs. water, cubic expansion coefficient, evaporation rate, parachor, Hansen's solubility parameters

2. Solids data:

Surface free energy or surface tension and their polar and dispersion forces contributions: Standard polymers, fluorine polymers, metals and ceramics (untreated and modified)

3. Perfluoro-alkanes (up to $C_{10}F_{22}$):

Analogy of the data of interfacial test liquids, additionally molecular data

We will also help you if you have special questions about interfacial parameters.

Some Internet links on the subject of surface chemistry

International Association of Colloid and Interface Scientists (IACIS): http://metten.fenk.wau.nl/iacis/iacis.html

European Colloid and Interface Society (ECIS): http://mat.ethz.ch/ecis/

Queen Mary and Westfield College, University of London: http://alpha.qmw.ac.uk/~ugca000/surfaces

Swedish Royal Institute of Technology: YKI Institute of Surface Chemistry, Stockholm: http://www.surfchem.kth.se

Paul Huibers »List of Surfactant Science Web Sites«, MIT, Cambridge, MA: http://www.mit.edu/~huibers/

University of Washington, The Interfacial and Colloid Science Group, Washington D.C.: http://weber.u.washington.edu/

Carnegie Mellon University, Interfacial Physics Group: http://info.phys.cmu.edu/interfacial/interfacial_index.html

Bristol Colloid Centre, Bristol: http://www.tlchm.bris.ac.uk/

Max-Planck-Institute of Colloids and Interfaces, Berlin: http://www.mpikg.fta-berlin.de

Institute of Polymer Research, Dresden: http://www.ipfdd.de/research/research.htm

Surface Science Laboratories Resource Links: http://surface-science.com/sslinks.html

The Institut of Physical and Chemical Research (RIKEN), Surface Chemistry Laboratory, Saitama: http://www.riken.go.jp/lab-www/surf-chem/index.html

Glossary of Surface Chemistry:

http://www.acs.ucalgary.ca/~schramm/glossary.html

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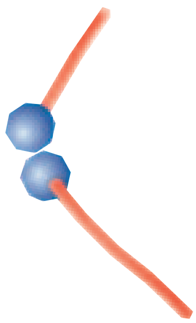

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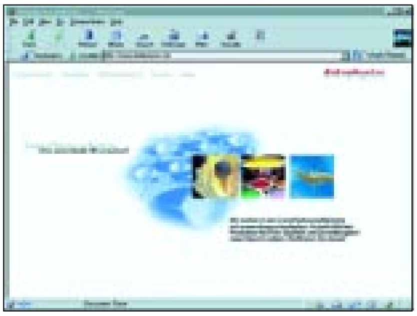

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