MBP 200

Bubble Pressure Tensiometer

dataphysics

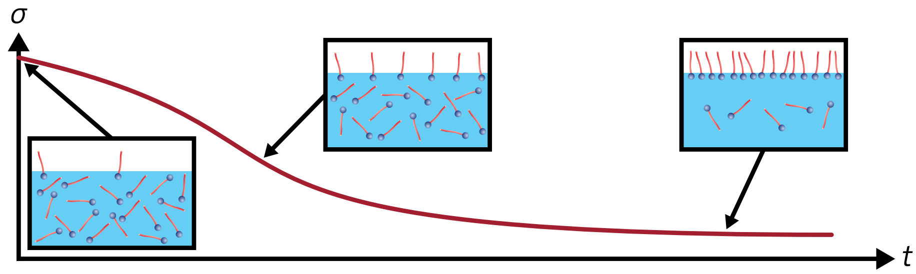
Dynamic Surface Tension Explained

The surface tension describes the work that has to be done to increase the surface area of a liquid against a gas phase, such as ambient air. It can be expressed in joules per square metre (J/m²) or in millinewtons per metre (mN/m). The surface tension is an important parameter for assessing how easily a liquid can be divided into droplets or distributed on a solid surface.

Surface-active substances, such as surfactants, prefer to accumulate on the surface due to their molecular structure. As soon as a new surface is created in a solution with surface-active substances, for example through the formation of gas bubbles, the surface-active substances begin to accumulate at the new surface. The number of surface-active particles per surface unit increases until an equilibrium is reached.

Dynamic vs. Static Surface Tension
Before equilibrium is reached, the surface tension is referred to as the 'dynamic surface tension'. The dynamic surface tension is often defined as a function of the surface age. The surface age is the time that has passed since the formation of the new surface. In practice, a decrease in surface tension is observed until the equilibrium is reached. In contrast, the surface tension value that can be measured after equilibrium has been reached is referred to as the 'static surface tension'.

Interfacial tension σ vs. time



The dynamic surface tension σ decreases with time as the surface-active substances accumulate at the surface. The static surface tension is established after the equilibrium is reached.

Maximum Bubble Pressure Method

The dynamic surface tension can be determined using the maximum bubble pressure method. This method utilises the fact that the pressure difference inside and outside a gas bubble in a liquid (Δp), the surface tension of this liquid (σ) and the curvature radius of the gas bubble surface (r_B) are related. This can be described by the Young-Laplace equation:

$$\Delta p = \frac{2\sigma}{r_B}$$

Experimental Set-Up
In the experimental set-up of the measurement, the liquid to be analysed is placed in a vessel under a capillary. The capillary opening is then immersed in the liquid. Next, gas flows through the capillary in a controlled volume flow and gas bubbles form at the opening of the capillary.

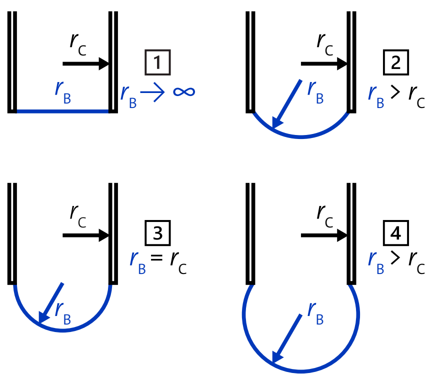
The volume of a gas bubble created this way grows steadily. At the beginning, the bubble has a large curvature radius, which gets smaller and smaller $\boxed{1}\rightarrow\boxed{2}$. At the same time, the pressure inside the bubble increases. When the gas bubble forms a hemisphere at the opening of the capillary, the curvature radius reaches a minimum and the pressure in the bubble reaches a maximum $\boxed{3}$. As the volume of the gas bubble continues to grow, the curvature radius begins to increase as the pressure decreases $\boxed{4}$ until the gas bubble finally breaks away from the capillary.

Moment of Maximum Bubble Pressure
The inner radius of the capillary opening (r_C) is the same as the curvature radius of the gas bubble surface when the maximum pressure within the bubble is reached ($r_C = r_B$) $\boxed{3}$. The inner radius of the capillary opening is determined by a previous calibration measurement with a liquid of known surface tension. The dynamic surface tension can then be calculated from the radius of the capillary opening – which at this moment is the same as the curvature radius of the gas bubble –, the measured pressure maximum, and the additionally calculated pressure outside the gas bubble.

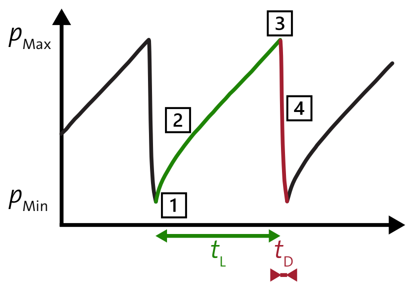
Surface Age and External Factors
From the moment a new bubble begins to form $\boxed{1}$ to the point at which the bubble is just hemispherical $\boxed{3}$, a certain period of time has elapsed. This period is known as the surface age (t_L). The subsequent time from the pressure maximum to the bubble rupture is referred to as the 'dead time' (t_D).

A bubble pressure tensiometer can vary the time at which the pressure maximum is reached. In this way, the dynamic surface tension can be determined for different surface ages. Since such processes are always dependent on external factors, the measurement should be carried out at a well-defined temperature and concentrations.

Development stages of a gas bubble



Bubble pressure p vs. time t



A gas bubble with a curvature radius r_B, suspended at the capillary opening with the inner radius r_C, goes through several stages of development. At the time of maximum bubble pressure $\boxed{3}$, the dynamic surface tension can be determined.

MBP 200 Bubble Pressure Tensiometer

The MBP 200 bubble pressure tensiometer from DataPhysics Instruments is a powerful measuring device for determining the dynamic surface tension of liquid solutions. To do so, it uses the maximum bubble pressure method.

The MBP 200 can direct a volume flow of gas through a capillary into a liquid, creating bubbles at the capillary opening. In order to track the pressure within the gas bubbles, the device contains a sensitive pressure sensor. On the basis of the detected pressure maxima, the surface age of the bubble and the dynamic surface tension is calculated. Additionally, the MBP 200 has a valve arrangement, which can generate volume flows of different strengths, in order to realise different surface ages for the measurement.

The MBP 200 can be used to determine dynamic surface tensions in the range between 10 mN/m and 100 mN/m for surface ages between 5 milliseconds and 200 seconds. This makes the device ideal for analysing liquids, such as surfactant solutions, in a wide dynamic range.

Various capillaries are available for the MBP 200. In addition to reusable glass capillaries, disposable capillaries can also be used.

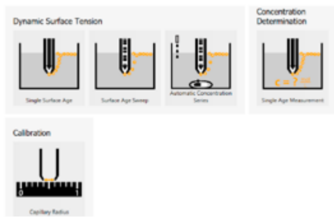
The temperature of the sample vessel can be set between -15 °C and 135 °C with the help of various optional temperature control units. This allows the dynamic surface tension to be analysed in dependence of the temperature.

The LDU 25 liquid dosing unit can vary concentrations automatically.

MBP 200 bubble pressure tensiometer with optional TP 50 control panel

Characteristics of the MBP 200

- Disposable plastic capillaries can be used in a wide dynamic range. They reduce the effort required for cleaning and prevent cross-contamination.
- The MBP 200 can measure high differential pressures up to over 3400 Pascal, which enables the analysis of highly viscous liquids, such as certain oils.
- With the optional LDU 25 liquid dosing unit, concentration series can be carried out automatically. This enables users to determine the dynamic surface tension for different surface ages as a function of the concentration, for example of a surfactant or additive, in a single measuring procedure.
- The sample vessel is surrounded by a splash guard, which reduces the cleaning effort.
- A collision protection mechanism prevents the capillary from colliding with the bottom of the vessel. This prevents damage to the capillary and the device.



Measurement options of the software

Software Features

The MBP software enables the device to be controlled and various measurements to be carried out:

- Single surface age: determining the dynamic surface tension for a given surface age
- Surface age sweep: determining the dynamic surface tension for a defined range of surface ages
- Automatic concentration series: the concentration of the solution is varied. The dynamic surface tension for different surface ages is determined for each concentration.
- Concentration determination using single age measurements: the dynamic surface tension of a solution of unknown concentration is determined for a single surface age. The concentration of the solution is then calculated.
- Determination of the adsorption and diffusion coefficients

Technical data

Dynamic surface tension	as a function of surface age or at a constant surface age
measuring range	10 ... 100 mN/m
measuring value rate	25,000 Hz
surface age	5 ... 200,000 ms
maximum differential pressure	3400 Pa
Sample stage	motorised with semi-automatic crash protection
traversing range	105 mm
traversing speed	46 nm/s ... 12 mm/s
travel resolution	24 nm
Temperature control	
via liquid circulator (-10 ... 130 °C)	optional
via Peltier element (-15 ... 135 °C)	optional
2 x Pt100 inputs for -60 ... +450 °C ± 0,01 K	integrated
TP 50 control panel	optional
LDU 25 liquid dosing unit	optional
Automatic magnetic stirrer	integrated
Dimensions (L [mm] x W [mm] x H [mm])	360 x 230 x 565
Weight	22 kg
Power supply	100 ... 240 VAC; 50 ... 60 Hz; 70 W

We will find a tailor-made solution for your surface science use case and will be pleased to provide you with an obligation-free quotation for the system that fits your needs. For more information please contact us.

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