The bubble pressure method for measuring the dynamic surface tension

Product: SITA tensiometer
Industry: Surfactant chemistry
Measuring principle: Measuring the dynamic surface tension

The surface tension of a liquid is a material constant as the density and the mass are. Surface-active substances such as surfactants (wetting agents) lower the surface tension of aqueous solutions, often concentration dependent. The surfactant concentration can thus be determined by measuring the surface tension.

Definition surface tension

The surface tension is equal to the work dW that has to be done per area dA to increase the surface of a liquid:

$$\sigma = \frac{dW}{dA}, [\sigma] = \frac{J}{m^2} = \frac{N}{m}$$

The intermolecular cohesion forces mutually abolish themselves in the liquid while the molecules lack the homogenous neighbours on the liquid surface. The resulting force F into the interior of the liquid causes the surface tension σ.

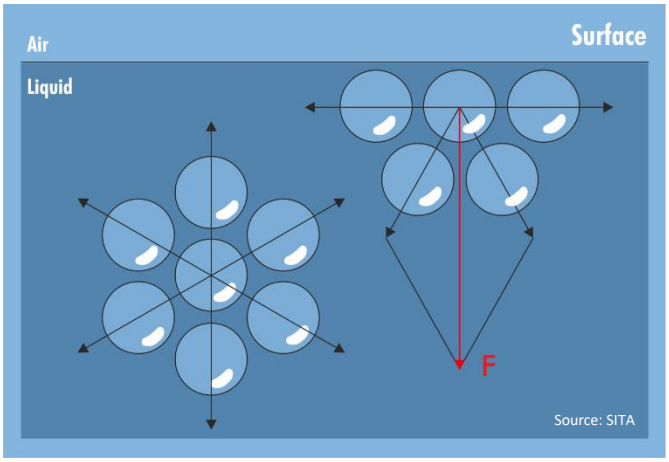

Figure 1: Applied forces in the inner liquid and at the surface

The surface tension is measured by increasing the surface using different methods.

Static measuring methods

Static measuring methods such as the ring or plate method increase the surface while pulling out the ring or plate until the surface breaks. The maximum breakaway force is equal to the surface tension. The methods are indicated as static, because they are independent of the elapsed time. Static measuring methods are therefore only suitable for pure liquids and low surfactant concentrations.

Dynamic measuring methods

With dynamic measuring methods such as the bubble pressure method the boundary surface expands steadily. Thus, the value of the surface tension depends on the timely deposition of the surface-active substances as well as the expansion of the boundary surface. Dynamic measuring methods are especially recommended for high surfactant concentrations in e.g. electroplating and cleaning baths. The specific adjustment of the surface age over the measuring time enables the measurement over a wide range of concentration

The time-dependent change of the surface tension is essential in numerous wetting and cleaning processes. Course, condition and result of those processes correlate decisively with the kinetics of the used surfactants.

Bubble pressure method

The bubble pressure method determines the maximal inner pressure of a gas bubble at the tip of a gas-perfused capillary in the liquid to be measured.

Figure 2: A small air bubble at the capillary tip is used as interface for measuring the dynamic surface tension.

Because this method can be automated, it permits the measurement of surface tensions for various lifetimes of liquid-gas-boundary surfaces.

When measuring the surface tension in accordance with the bubble pressure method, the radius of the formed

SITA Messtechnik GmbH . +49 (0) 351 / 288 53-0 . info@sita-messtechnik.de . www.sita-messtechnik.de

The bubble pressure method for measuring the dynamic surface tension

Product: SITA tensiometer
Industry: Surfactant chemistry
Measuring principle: Measuring the dynamic surface tension

bubble reduces permanently until the bubble radius equals that of the capillary R_K and the gas pressure reaches it maximum p_{max}. The gas bubble expands and breaks away from the capillary.

Das Verfahren erlaubt aufgrund seiner Automatisierbarkeit die Messung von Oberflächenspannungen bei verschiedenen Oberflächenaltern der Flüssigkeits-Gas-Grenzflächen. In accordance with the Laplace-equation, the maximal pressure p_{max} and the surface tension σ correlate:

$$\sigma = \frac{R_K}{2}(p_{max} - p_{stat}) = \frac{R_K}{2}(p_{max} - \rho g h_E)$$

The hydrostatic pressure p_{max} is therefore dependent on the immersion depth of the capillary h_E and the density of the liquid ρ.

Differential pressure method

SITA enhanced the bubble pressure method into the differential pressure method, whereby the hydrostatic induced pressure p_{stat} is eliminated. With the evaluation of the pressure minimum p_{min}, the measurement of the surface tension is independent of the immersion depth of the capillary. The capillary radius does not have to be exactly known, because SITA tensiometer can be calibrated with water at any time. During calibration, the tensiometer determines, by the pressure signal and the surface tension of water, how the measurement is influenced by the capillary or rather the capillary radius (calibration factor K).

$$\sigma = K(p_{max} - p_{min})$$

The actual bubble lifetime t_{life} is also known as surface age and corresponds to the time at which surface-active substances attach to the boundary surface. It comprises the period from the beginning of the bubble's formation in the capillary (time at which the pressure-minimum p_{min} prevails) to the moment at which the radius of the bubble is equal to the capillary radius R_K.

During a measurement, the bubble frequency is set to the selected value and kept constant even with a changing surface tension. Thus, time-dependent changes of the liquid characteristics can be recorded and monitored online up to several days.

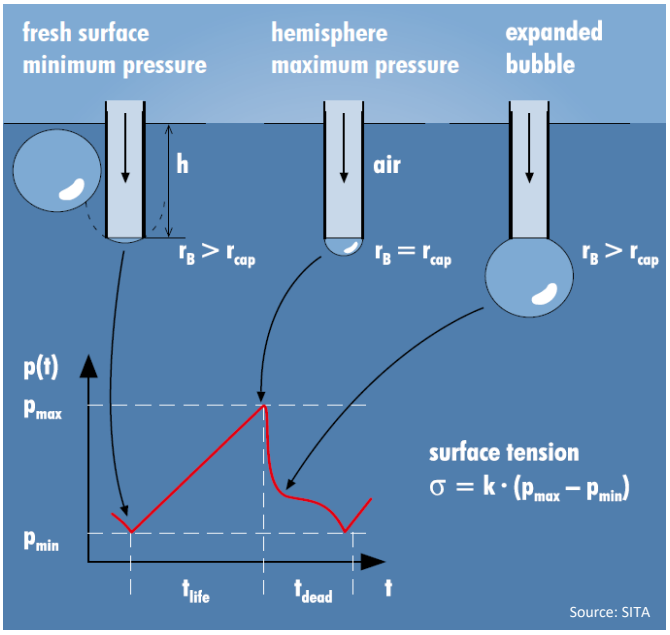

Figure 3: SITA bubble pressure method

SITA Messtechnik GmbH . +49 (0) 351 / 288 53-0 . info@sita-messtechnik.de . www.sita-messtechnik.de