Dynamic Surface Tensions as Measured by the Bubble Pressure Analyser BPA-1P

With the BPA-1P dynamic surface tensions can be measured in the time range between 10 ms and 10 s. A time interval reaching from less than 1 ms up to about 100 s can be reached with our BPA-1S. In the experiments either the standard or the fast measurement modus can be. The data obtained from the BPA-1P with the format *.bpa are given in a text format and can be imported into any graphic tool. Typically, only the adsorption time and the surface tension are needed. The data obtained for a solution of 2 g/l Triton X-100, a frequently use nonionic surfactant, are shown in the following table, measured in a time interval between 10 ms up to about 10 s.

Solution: 2 g/l Triton X-100

1	2	3	4	5	6	7	8	9	10	11
No.	Time, s	Temp, C	Press. Pa	ST raw, mN/m	Flowrate mm³/s	Bubble time, s	Dead time, s	Life time, s	Time Effect., s	ST mN/m
1	67.5	23.4	1157.1	72.65	83.9	0.045	0.036	0.009	0.005	68.66
2	78.8	23.3	1112.9	69.75	72.3	0.06	0.045	0.015	0.01	67.19
3	90.2	23.3	1078.2	67.48	57.5	0.084	0.052	0.032	0.019	65.94
4	101.6	23.3	1048.1	65.5	42.7	0.129	0.062	0.068	0.039	64.55
5	109.3	23.2	1030.5	64.35	34.1	0.17	0.066	0.103	0.058	63.62
6	121	23.2	1010.3	63.03	24.2	0.231	0.07	0.161	0.089	62.48
7	133.3	23.2	986.7	61.48	13.9	0.325	0.075	0.25	0.135	61.09
8	141.4	23.2	970.3	60.4	13.2	0.405	0.077	0.328	0.175	60.1
9	149.8	23.2	956.6	59.5	12.5	0.488	0.073	0.414	0.219	59.28
10	158.4	23.2	942.1	58.55	4.6	0.61	0.082	0.529	0.276	58.4
11	167	23.2	926.4	57.53	2.5	0.753	0.082	0.671	0.347	57.43
12	176.1	23.1	911.2	56.53	2.2	0.952	0.082	0.871	0.446	56.47
13	184.7	23.2	896.7	55.58	0	1.204	0.087	1.118	0.567	55.58
14	193.5	23.2	883.4	54.7	0	1.523	0.086	1.437	0.723	54.7
15	203	23.2	871.2	53.9	0	1.93	0.086	1.844	0.921	53.9
16	212.8	23.2	859.7	53.15	0	2.524	0.086	2.438	1.211	53.15
17	242.1	23.2	842.6	52.03	0	3.148	0.091	3.057	1.504	52.03
18	260.4	23.2	832.3	51.35	0	3.879	0.089	3.79	1.856	51.35
19	274.2	23.2	825	50.88	0	4.644	0.089	4.555	2.223	50.88
20	300.6	23.1	814.7	50.2	0	5.579	0.088	5.49	2.666	50.2
21	315	23.2	807.9	49.75	0	7.286	0.091	7.195	3.483	49.75
22	333.1	23.2	801	49.3	0	8.727	0.096	8.632	4.166	49.3
23	355.5	23.1	793.8	48.83	0	10.995	0.093	10.902	5.245	48.83

The column 2 shows the times elapsed from the beginning of the experiment. Here the entire experiment took about 11 minutes. Column 4 and 6 contain technical raw data – pressure and gas flow rate. In column 7 to 9 the bubble time t_b, the deadtime t_d and the lifetime t are given ($t_b = t_l + t_d$). The final surface tension (after all necessary corrections) is given in column 11, while the uncorrected values are given in column 5. Column 3 gives the actual temperature.

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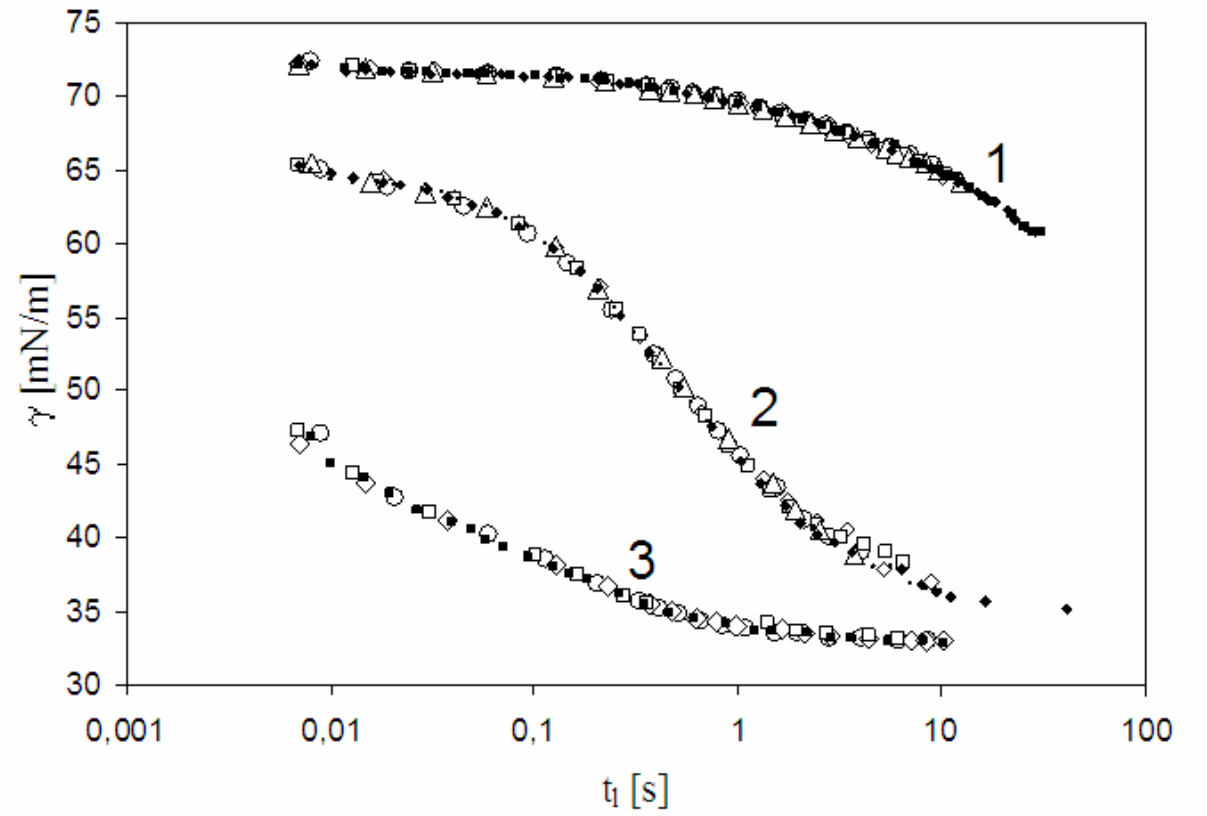
A suitable software to display the results graphically is MS EXCEL. The data can be easily imported into an EXCEL worksheet. The following graphics shows the time dependence of three different concentrations of Triton X-100. The typical S-shape obtained when plotted versus the logarithm of time is caused by the adsorption process of the surfactant molecules to the solution-air interface. At the lowest concentrations ($c = 8 \cdot 10^{-5}$ mol/l) the beginning of the adsorption dynamics is well obtained while a final time of 10 s is insufficient to reach equilibrium, i.e. constant surface tension with time. For the highest surfactant concentrations of $3.2 \cdot 10^{-3}$ mol/l (refers to 2 g/l) the equilibrium surface tension has been reached, however, the beginning of the adsorption process was missed because the values at the lowest time are already below 50 mN/m.



Even the dynamic surface tension of the $8 \cdot 10^{-4}$ mol/l Triton X-100 solution (curve 2), does not start at surface tensions close to that of water. This is due to an initial load of the bubble surface caused by the fast adsorption of the Triton molecules at this concentration. The open symbols were measured in the fast modus of the BPA-1P, while the standard modus (small closed symbols) yields more data points (about 25 to 30). The agreement between the two procedures is however perfect.

In order to obtain a complete picture of the adsorption process, for the low concentrations measurements at longer adsorption times would have to be performed, for example by the PAT-1, while for the higher concentrations, additional experiments at shorter times are required, which is possible for example by using the bubble pressure tensiometry BPA-1S (values down to less than 1 ms).
Using a theoretical model, the adsorption mechanism of the studied surfactant can be analysed. Algorithms and procedures for such an analysis have been described in a book recently published (*Surfactants – Chemistry, Interfacial Properties and Application, Studies in Interface Science, V.B. Fainerman, D. Möbius and R. Miller (Eds.), Vol. 13, Elsevier, 2001*).

Our service:

- selection of the right experimental technique for a given surfactant
- measurement of dynamic surface tensions over a respective adsorption time
- data analysis and graphical representation
- analysis of the adsorption mechanism
- proposal of other complementary techniques if needed
- compare with standard surfactants
- reference to literature data
- literature analysis to the subject