Technical note

Delta-8 multichannel microtensiometer: determination of critical micelle concentration of 1,2-dioctanoyl-sn-glycero-3-phospocholine in water

Christoffer Johans and Pekka Suomalainen

June 13, 2003

Overview

The purpose of this technical note is to show the capability to measure and characterize highly surface active compounds with low critical micelle concentrations (CMC) with Kibron's Delta-8 multichannel microtensiometer. For this purpose eight equivalent dilution series were prepared and measured. The characteristic parameters obtained from the analysis of each isotherm were compared by common statistical means.

Experimental

Surface tension measurements were carried out on a Delta-8 multichannel microtensiometer in standard configuration. The instrument utilizes eight parallel microbalances fixed to meet the positions of the wells in a 96 format. The surface tension measurement is based on the Du Nouy method, i.e the maximum force exerted by the surface tension is recorded as the probes are withdrawn from the solutions. The resolution of the balances is 0.05 mN/m. The probes have a diameter of 0.5 mm and the measurement solution is completely wetting their surface. The instrument features an automatic cleaning of the probes by heating prior to the measurement of the 96-well plate. One measurement cycle, i.e. the heating of the probes and the measurement of the 96-wellplate, takes less than 2 min.

A dilution series was prepared by the following steps: 50μl of 1.2 mM 1,2-dioctanoyl-sn-glycero-3-phospocholine (diC$_8$PC) (Avanti Polar Lipids Inc.) (diC$_8$PC) in water was placed in each well in column 1 of a 96-well plate (Kibron Inc.). The rest of the columns were filled with 25 μl water. 25 μl was transferred from column 1 to column 2 and the contents were mixed. These steps were repeated until column 11 was reached. 25 μl was removed from column 11 and 25 μl of water was added to all wells and the contents were mixed. Thus, eight parallel dilution series were obtained starting from 0.6 mM diC$_8$PC. The concentration in the successive columns were $0.6 \times 2^{-(n-1)}$ mM, where n is the column number. Column 12 contained pure water as a reference value. MQ-water (Millipore) was used throughout.

The adsorption isotherms were measured and analyzed as described elsewhere [1].

Results and discussion

The obtained adsorption isotherms are shown in Figure 1. The air/water partitioning coefficient, K_{aw}, the cross-sectional area, A_{s}, and the CMC obtained from fitting are given in Table 1. The mean value, standard deviation and coefficients of variation are collected in Table 2. This table also shows the free energies related to the air/water partitioning and the micelle formations.

Generally, it is difficult to quickly, without compromising accuracy and precision, measure low CMC values, and the sensitivity to these are dependent on

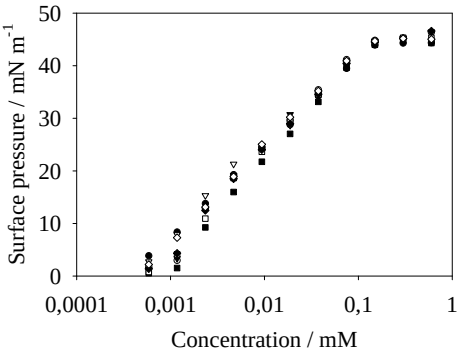

Figure 1: Adsorption isotherms of diC_8PC obtained from the eight parallel dilution series. The CMC can be seen as a break in the slope of the isotherms.

Table 1: K_{aw}, A_s and CMC for the individual isotherms.

	K_{aw}/mol^{-1}	A_s/Å^2	CMC/mM
A	2960000	57	0.15
B	1970000	50	0.13
C	2530000	53	0.14
D	1660000	50	0.14
E	1250000	48	0.13
F	1900000	51	0.13
G	2130000	52	0.15
H	2440000	53	0.13

the technique used. In this respect surface tension measurements, *i.e.* adsorption isotherms, offer an interesting possibility as the accuracy and precision of the method is, *in principle* independent of the applied concentration, since the surface tension that is probed is directly related to the chemical potential, and thus, to the free concentration of the considered species. It must, however, be noted that liquid handling of surface active compounds with low concentrations is more difficult, which results in lower precision.

The CV% obtained in this study (CMC 5.6% and A_s 5.3%) compares favorably with those obtained for SDS (CMC 3.3% and A_s 2.1%) [2], which indicates only a slight decrease in precision with a 40-fold decrease in CMC.

Concluding remarks

This study shows that the Delta-8 is capable of measuring compounds with moderate CMCs precisely and quickly. The instrument is thus suited for screening and characterization of surfactant solutions when low compound consumption and throughput are required.

References

[1] P. Suomalainen, C. Johans, and P. K. J. Kinnunen. Surface activity profiling (sap) of drugs applied to the prediction of blood-brain barrier permeability. *Submitted*, 2003.

[2] P. Suomalainen, C. Johans, and P. K. J. Kinnunen. Technical note: Delta-8 multichannel microtensiometer: intra- and inter-assay precision. *www.kibron.com*, 2003.

Table 2: Mean and standard deviation of the CMC and K_{aw}, and their respective free energies.

	K_{aw}/mol^{-1}	$RT \ln K_{aw}^{-1}/$ kJ mol^{-1}	$A_s/\text{Å}^2$	CMC/mM	RT lnCMC/ kJ mol^{-1}
Mean	2100000	-35.6	52	0.14	-21.8
SD	538000	0.7	3	0.008	0.14
CV%	25.6	1.9	5.3	5.6	0.6