

## Delta-8 multichannel microtensiometer: Influence of DMSO on the CMC of SDS

Christoffer Johans, Pekka Suomalainen

March 18, 2004

### Overview

The purpose of this technical note is to show the versatility of the Delta-8 instrument for systematically studying how the chemical environment affects the behavior of surfactants. Pharmaceutical development today shows a trend towards larger drugs that are less soluble in aqueous media. With the use of a co-solvent the solubility can be enhanced, but at the same time the physico-chemical properties of primary compound are shifted. In particular, this study shows how DMSO affects the critical micelle concentration (CMC) of sodium dodecyl sulfate (SDS) in aqueous solution.

### 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-well format. The resolution of the balances is 0.05 mN/m. The surface tension measurement is based on gravimetric procedure i.e the maximum force exerted by the surface tension is recorded as the probes are withdrawn from the solutions. The probes have a diameter of 0.5 mm and the measurement solution is completely wetting their surface. The instrument features automatic cleaning of the probes by heating prior to the measurement of the 96-well plate. The measurement loop, i.e. the cleaning of the probes and the measurement of the 96-well plate, takes less than 2 minutes.

A serial dilution of aqueous sodium dodecyl sulfate (SDS) was prepared, such that the concentrations were  $100 \times 0.619^{(n-1)}$  mM, where  $n$  ranges from 1 to 11. SDS was obtained from SERVA and was used as received without further purification. MQ-water (Millipore) was used throughout. All liquid handling was conducted by manual pipetting (Biohit Proline) into disposable 96-well plates. 30  $\mu$ l of the dilution series was transferred to the corresponding wells on the detection plate followed by the addition of various amounts of dimethylsulfoxide (Merck) (DMSO) to each row. Finally, water was added until a final volume of 50  $\mu$ l per each well. Thus, the final dilution series obtained contained  $60 \times 0.619^{(n-1)}$  mM SDS, and DMSO as follows: (rows A-H) 0, 2, 4, 6, 8, 10, 12, and 14 % by volume. Another detection plate was prepared accordingly, but contained DMSO as follows: (rows A-E) 12, 16, 20, 24 and 28 % by volume. The contents of the plates were mixed thoroughly by aspirating and dispensing. The plates were allowed to equilibrate for 10 minutes under a lid prior to the measurement. The plates were measured in order of increasing surfactant concentration to minimize carry over, i.e. from column 12 to 1. The isotherms were analyzed with the Gibbs adsorption model embedded in the Delta-8 Manager software. The instrument was calibrated before the measurements by adjusting the measurement scale so that the surface tension of water corresponded to 72.8 mN/m (standard calibration routine).

## Results and discussion

The CMCs are shown as a function of DMSO fraction in Figure 1. The CMC values increase with increasing DMSO content. In the case of SDS this increase seems fairly linear with respect to the volume % of DMSO. It can be concluded that this type of experiment can be used to find the aqueous CMC by extrapolating to zero DMSO fraction. This is important for poorly soluble compounds that require co-solvents, e.g. DMSO.

Figure 2 shows the difference in surface tension values ( $\Delta\gamma$ ) between the columns 12 and 1 for systems with varying amounts of DMSO. It is noted here that the minimum surface tension measured for the SDS in pure aqueous solvent is smaller than in the water/DMSO mixtures (data not shown). Thus, the less hydrophilic nature of the DMSO/water mixture reduces the driving force for interfacial partitioning of the surfactant.

Figure 3 shows how the cross-sectional area of SDS is affected by the DMSO content. The cross-sectional area increases with increasing DMSO content. Thus, the packing of the SDS molecules in the surface layer is less important in the presence of DMSO. Qualitatively, this can be explained by the smaller driving force for excluding the hydrocarbon tails in presence of DMSO, giving the hydrocarbon chains larger conformational freedom. Electrostatic effects due to longer screening lengths in the water/DMSO mixtures should also be considered.

All these figures show that by increasing the amount of DMSO favorably interacts with the dodecyl hydrocarbon chain, thus making the SDS molecule more soluble. This interaction is mainly due to the high organization of water around hydrophobic groups, that decreases the entropy of the system. This is commonly referred to as the hydrophobic effect. Strongly hydrophilic groups are better solvated by water, while the solvation of hydrophobic groups are favored by the addition of DMSO. Thus, the balance between hydrophilic and hydrophobic groups is

expected to determine how the CMC and the surface properties are affected.

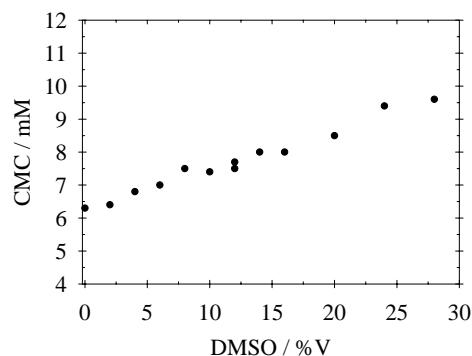


Figure 1: Dependence of critical micelle concentration of aqueous SDS solutions on the fraction of DMSO.

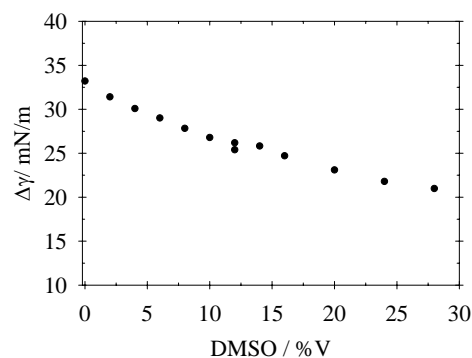


Figure 2: Dependence of the observed surface tension difference of aqueous SDS solutions on the fraction of DMSO.

## Concluding remarks

It is shown that this type of experiments are suitable for finding the CMC in aqueous solution by extrapolating to zero co-solvent concentration. More generally, the above results demonstrate the feasibility of the Delta-8 for extracting information from large chemical environment spaces. This type of experiments are very demanding and time consuming by conventional surface tension methodology.

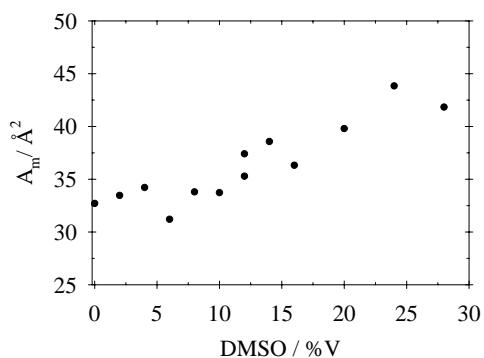


Figure 3: Dependence of the interfacial cross-sectional area of SDS on the fraction of DMSO in the aqueous solution.