Experimental report

13/06/2021

Proposal: EASY-646 **Council:** 4/2020

Title: Interactions of mixed nonionic-ionic surfactant micelles determined by SANS

Research area: Soft condensed matter

This proposal is a new proposal

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Experimental team:

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Samples: NaC12H25SO4

Instrument	Requested days	Allocated days	From	To
D11	12	12	15/08/2020	16/08/2020

Abstract:

The aim of this work is to resolve the structure and interactions in mixtures of nonionic-ionic surfactant micelles (nonionic: Tween 20, ionic: SDS). Doping of uncharged surfactant micelles with ionic surfactants can be used for a very precise control of the micellar charge and therefore the intermicellar interactions. By using SANS we want to determine the micelles bulk nanostructure (i.e. the micellar shape (extracted from P(Q)) as well as their interactions(extracted from S(Q))).

This understanding will act as the basis for the descirption of the interactions of two solid surfaces throughout micellar dispersions. Those interactions are often determined by the dispersions nanostructure, the so called 'structural forces'.

Interactions of mixed nonionic-ionic surfactant micelles determined by SANS

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Date Performed: 15/08/20
Proposal number EASY 646
Beamline: D11

EXPERIMENT DESCRIPTION AND OBJECTIVES

Please refer to doi:10.5291/ILL-DATA.EASY-440 for details on Materials, Methods and Data analysis.

PRELIMINARY RESULTS

Non ideal behaviour of mixed nonionic-anionic micelles

Fig. 1 shows SANS data of mixed SDS/Tween20 micelles at various mixing ratios X, starting from $X = 0.00$ (pure Tween20) to $X = 1.00$ (pure SDS) with similar total surfactant concentrations (142 - 187 mM).

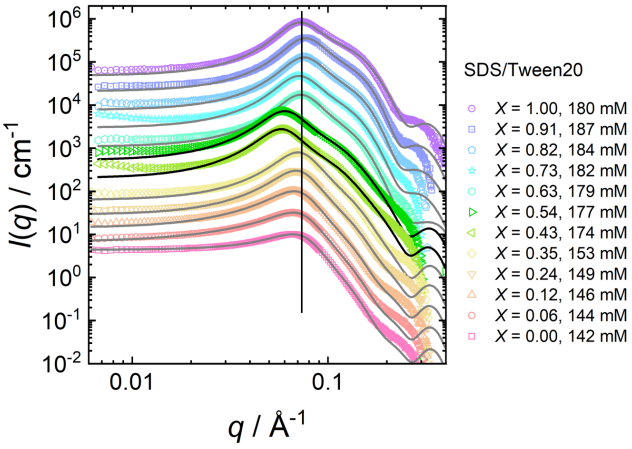

FIG. 1. SANS data for mixed Tween20-SDS surfactant mixtures at similar surfactant concentrations but at varying mixing ratios $X = [\mathrm{SDS}] / ([\mathrm{SDS}] + [\mathrm{Tween20}])$. Symbols are experimental scattering data. The black solid lines are model fits to the data. Data sets are scaled with a factor of 3^n for clarity.

Table I summarises the parameters extracted from the SANS model fits (core-shell ellipsoid + RMSA structure factor; pure Tween20: HS-PY structure factor) of SDS/Tween20 solutions. Fitted values: volume fraction ϕ, axial ratio of the core x_c, shell thickness t_s, shell scattering length density ρ_s, and the charge per micelle z. Calculated values: the effective radius r_{eff}, the aggregation number N_{agg}, and the fractional charge β.

TABLE I. Parameters extracted from SANS model fits (core-shell ellipsoid form factor + RMSA structure factor; pure Tween20: HS-PY structure factor) of mixed SDS/Tween20 surfactants in D_2O at 20.0 °C (*fixed values).

X	c mM	ϕ	x_c	t_s nm	$\rho_s \cdot 10^{-6}$ Å^{-2}	r_{eff} nm	N_{agg}	β
0.00	142	0.240	2.14	1.78	5.08	3.99	95	–
0.06	143	0.257	2.17	1.80	5.14	4.03	92	0.06
0.12	146	0.270	2.17	1.82	5.21	4.05	90	0.10
0.24	149	0.278	2.12	1.78	5.33	3.99	86	0.16
0.35	153	0.268	1.96	1.71	5.47	3.85	82	0.20
0.43	174	0.231	3.15	1.83	5.67	4.43	166	0.12
0.54	177	0.215	2.89	1.67	5.77	4.17	150	0.13
0.64	179	0.150	1.73	1.08	5.33	3.12	91	0.24
0.73	182	0.104	1.77	0.80	5.15	2.84	100	0.24
0.82	184	0.111	1.57	0.78	5.33	2.74	86	0.28
0.91	187	0.096	1.50	0.65	5.29	2.58	84	0.32
1.00	180	0.090	1.72	0.69*	6.34*	2.71	99	0.27

Intermicellar structuring at various volume fractions

At large volume fractions of dispersed micelles, the excluded volume effect is the dominant driving force for intermicellar structure. The scattering data of mixed SDS/BrijL23 micellar dispersions, with a mixing ratio of $X = 0.32$ and a total surfactant concentration of 127 mM was fitted with both, the RMSA and the HS-PY structure factor $S(q)$ for comparison. Fig. 2 shows that the results from both methods agree well with each other.

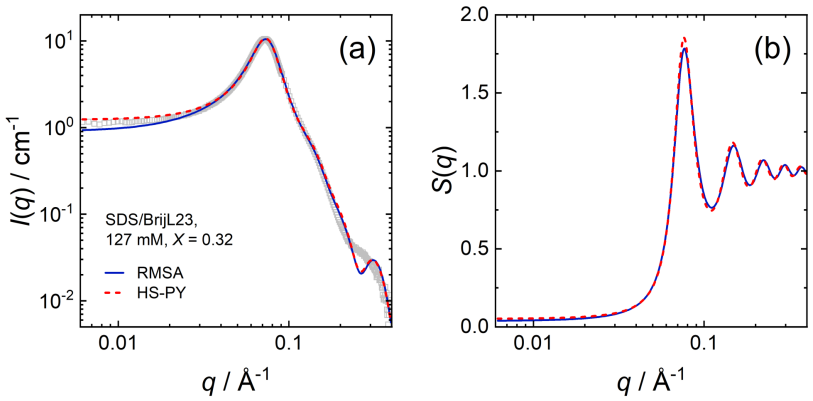

FIG. 2. (a) SANS data for the SDS/BrijL23 mixture with a total surfactant concentration of 127 mM and a mixing ratios $X = [\mathrm{SDS}]/([\mathrm{SDS}]+[\mathrm{BrijL23}]) = 0.32$. Symbols are experimental scattering data. Two model fits to the data are compared: the blue, solid line is fitted using the RMSA structure factor. The red, dashed line is the result using the HS-PY structure factor. Extracted structure factors $S(q)$ are displayed in panel (b).

Table II summarises the parameters extracted from the SANS model fits (core-shell ellipsoid + both structure factors). Fitted values: volume fraction ϕ, axial ratio of the core x_c, shell thickness t_s, shell scattering length density ρ_s, and the charge per micelle z. Calculated values: the effective radius r_{eff}, the aggregation number N_{agg}, and the fractional charge β.

TABLE II. Parameters extracted from SANS model fits (core-shell ellipsoid form factor + RMSA or PY structure factor) of mixed SDS/BrijL23 surfactants in D_2O at 20.0 °C with a total surfactant concentration $c = 127$ mM and a mixing ratio $X = 0.32$.

$S(q)$	ϕ	x_c	t_s nm	$\rho_s \cdot 10^{-6}$ Å^{-2}	r_{eff} nm	N_{agg}	β
RMSA	0.360	1.93	2.09	5.61	4.23	67	0.11
HS-PY	0.371	2.01	2.14	5.67	4.30	68	–