Experimental report

13/05/2022

Proposal: 9-10-1598 **Council:** 4/2019

Title: To investigate the unusually strong synergetic effect of the mixture of the sulfobetaine and biosustainable/biodegradable MES Surfactants

Research area: Soft condensed matter

This proposal is a new proposal

Main proposer: **Peixun LI**

Experimental team: Armando MAESTRO
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Local contacts: Armando MAESTRO

Samples: C12sulfobetaine
C14 methyl ester sulfonate

Instrument	Requested days	Allocated days	From	To
FIGARO	3	3	21/06/2021	24/06/2021

Abstract:

Zwitterionic surfactants carry no net charge at the natural pH with no added electrolyte. This lack of overall charge makes their interactions with bio-systems weaker than those of ionic surfactants. The presence of charges within the overall neutral molecule generally makes them interact strongly with ionic surfactants. The methyl ester sulfonate, MES, represents a promising group of anionic surfactants with improved performance and biocompatibility/biosustainability. Recent surface tension and light scattering measurements have shown unexpected strong asymmetric synergy between these two components, and this has potentially important implications for a wide range of applications. However neutron techniques are now essential in order to understanding this potentially important phenomenon in detail and to discern the underlying mechanism. We request beam time on FIGARO to investigate the interfacial structure of MES/sulfobetaine mixtures to determine the variation in surface composition and structure with solution concentration and composition. The proposal complements a separate proposal using SANS to study the related self-assembly properties.

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The milder interaction with biosystems makes the zwitterionic surfactants an important class of surfactants, and they are widely used in biological applications and in personal care formulations. An important aspect of those applications is their strong synergistic interaction with anionic surfactants.

We have combined the serval techniques, i.e. surface tension, ST, neutron reflectivity, NR, and small angle neutron scattering, SANS, to explore the synergistic mixing in micelles and at the air-water interface for the zwitterionic surfactant, dodecyldimethylammonium propanesulfonate, C_{12}SB, and the anionic surfactants, alkyl ester sulfonate, AES, in the absence and presence of electrolyte, 0.1 M NaCl. The partial of NR experiment were carried out on FIGARO. At the air-water interface the asymmetry of composition in the strong synergistic interaction and the changes with added electrolyte and anionic surfactant structure reflect the relative contributions of the electrostatic and steric interactions to the excess free energy of mixing.

The results show how a comprehensive set of experimental data for mixed surfactants, encompassing variations in cmc, surface compositions and structure, enables a more detailed thermodynamic analysis which reveal the nature of the strong synergistic interaction. Also importantly it shows how the nature of the interaction between zwitterionic surfactants and co-surfactants can be manipulated to adjust and enhance surface adsorption and manipulate solution self-assembly properties. This provides exciting opportunities for a wide range of potential formulations. This is particularly relevant for personal care products and biological applications, where mildness, reduced toxicity and improved biodegradability are important factors.

This work has been published on ***Journal of Colloid and Interface Science***, 2022, 613, 297-310, Kun Ma, Peixun Li, Zi Wang, Yao Chen, Mario Campana, James Doutch, Robert Dalgliesh, Armando Maestro, Robert K Thomas, Jeff Penfold, *Strong synergistic interactions in zwitterionic–anionic surfactant mixtures at the air–water interface and in micelles: The role of steric and electrostatic interactions*, https://doi.org/10.1016/j.jcis.2022.01.045.