Correlation of foam film stability to the interfacial composition and structure of polyelectrolyte/surfactant mixtures

Richard A. Campbell[1*], Heiko Fauser[2], Martin Uhlig[2] and Regine von Klitzing[2]

[1]*Large Scale Structures, Institut Laue-Langevin, Grenoble, France*
[2]*Institute of Chemistry, Technical University Berlin, Berlin, Germany*

**campbell@ill.eu*

The properties of foams are of interest for many industrial applications such as enhanced oil recovery and in personal care products, and as such they are the focus of many studies [1]. A way to produce stable foam films is to mix surfactants with oppositely charged polyelectrolytes, as the synergistic co-adsorption of the components reduces the free energy of the air/water interface and facilitates bubble formation.

We started our work with mixtures of the flexible polyelectrolyte poly(acrylamidomethyl propanesulfonate) sodium salt (PAMPS) and tetradecyltrimethylammonium bromide (C_{14}TAB) showing that there was not a direct correlation between the foam film stability and the surface tension [2]. Then we applied neutron reflectometry to the same system to resolve the surface excess of each component at the interface (i.e. the interfacial composition). We showed that a peak in surface tension can be rationalized in terms of the changing surface composition with bulk composition, rather than bulk precipitation, and the highest foam film stability occurs when there is enhanced synergistic adsorption of both components at the interface due to charge screening when the ionic strength of the system is highest [3].

It was still unclear, however, the influence of the location of the components at the surface (i.e. the interfacial structure) on the resulting foam film properties. Very recently we have studied C_{14}TAB mixed with a newly synthesized polyelectrolyte, monosulfonated poly(phenylene sulfone) ($sPSO_2$-S220) [4], which has a stiffer backbone than PAMPS. This mixture leads to even more stable foam films [5]. Our latest work provides a missing link to the interfacial structure: the most stable films involve a highly hydrated and extended polyelectrolyte monolayer bound with 1:1 stoichiometry to a surface monolayer of surfactant, whereas the least stable films involve a multilayer arrangement at the interface [6].

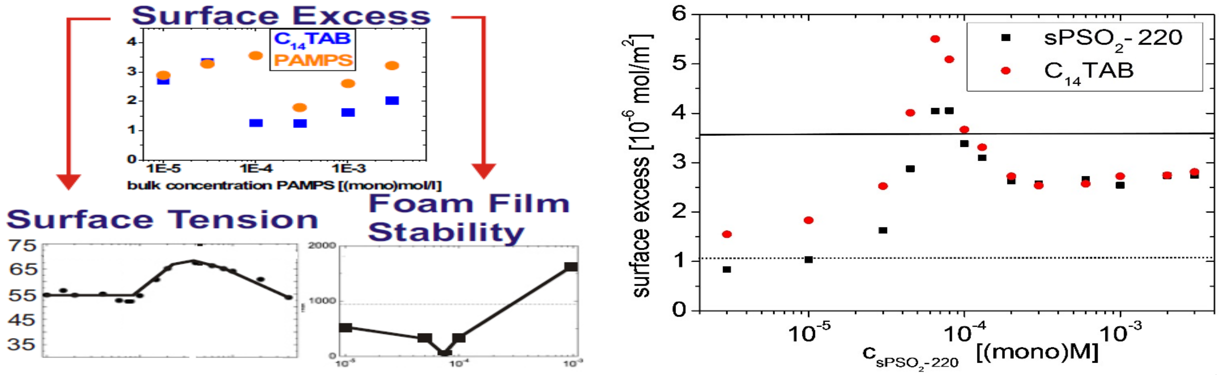

Figure. (*left*) graphical abstract from ref. 3 summarizing our work to relate the interfacial composition in µmol/m^2 of PAMPS/C_{14}TAB mixtures (top) to the surface tension (bottom left) and foam film stability (bottom right); (*right*) new data showing non-monotonic changes in the interfacial composition of $sPSO_2$-220/C_{14}TAB mixtures (at 10 mM C_{14}TAB).

[1] R. Petkova, S. Tcholakova & N. Denkov, *Langmuir*, 2012, **28**, 4996.

[2] N. Kristen, V. Simulescu, A. Vüllings, A. Laschewsky, R. Miller and R. v. Klitzing, *J. Phys. Chem. B*, 2009 **113**, 7986.

[3] H. Fauser, R. v. Klitzing & R. A. Campbell, *J. Phys. Chem. B*, 2015, **119**, 348.

[4] M. Schuster, C. C. de Araujo, V. Atanasov, H. T. Andersen, K.-D. Kreuer & J. Maier, *Macromolecules*, 2009 **42**, 312.

[5] M. Uhlig, R. Miller & R. v. Klitzing, Phys. Chem. Chem. Phys. 2016, **18**, 18414.

[6] M. Uhlig, R. v. Klitzing & R. A. Campbell, 2016, **in preparation**.