

The Physics of Soft and Biological Matter

New method to predict the surface tension of complex synthetic and biological polyelectrolyte/surfactant mixtures

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While the surface tension of complex mixtures determines the fate of important natural processes like the stability of aerosol droplets in clouds and the biological function of lung surfactants, the property is notoriously difficult to interpret and model. For example, it was established over a decade ago that some strongly interacting polyelectrolyte/surfactant (P/S) mixtures exhibit a striking cliff edge peak in their surface tension isotherms [1]. Recently we have systematically linked the surface tension peak of a strongly interacting P/S mixture to slow dynamic changes in its bulk phase behavior [2], and we went on to demonstrate the non-equilibrium nature of the system [3]. Here we announce a simple new approach that successfully predicts the surface tension of two synthetic (Pdadmac/SDS and NaPSS/DTAB) and one biologically-relevant (DNA/DTAB) mixtures [4]. The approach is based on the non-equilibrium framework of comprehensive precipitation of kinetically-trapped aggregates followed by their transport under gravity away from the probed interface. Importantly our approach does not need any measurements of the surface properties of the mixtures; only the surface tension isotherm of the pure surfactant and some bulk measurements of the mixtures are required. This simplification in our understanding of the surface properties of strongly interacting mixtures may lead to the optimization of a broad range of applications involving commercial synthetic polymers, DNA and proteins at surfaces, such as in common household formulations and rapidly expanding research areas such as targeted drug and gene delivery.

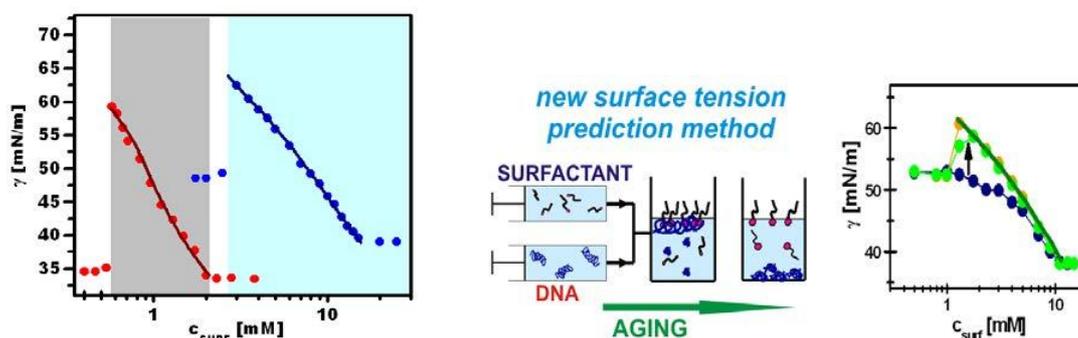


Figure. Left. Surface tension of aged Pdadmac/SDS (red) and NaPSS/DTAB (blue) solutions with our predictions of the surface tension which are not based on any surface measurements of the mixtures; shaded area indicates the phase separation regions. Right. Table-of-contents image from our recent letter in *Langmuir* [4] showing the prediction for aged DNA/DTAB mixtures.

- [1] Staples, E.; Tucker, I.; Penfold, J.; Warren, N.; Thomas, R. K. Organization of polymer–surfactant mixtures at the air–water interface: sodium dodecyl sulfate and poly(dimethyldiallylammonium chloride). *Langmuir* 2002, 18, 5147–5153
- [2] Campbell, R. A.; Angus-Smyth, A.; Arteta, M. Y.; Tonigold, K.; Nylander, T.; Varga, I. New perspective on the cliff edge peak in the surface tension of oppositely charged polyelectrolyte/surfactant mixtures. *J. Phys. Chem. Letters* 2010, 1, 3021–3026
- [3] Campbell, R. A.; Arteta, M. Y.; Angus-Smyth, A.; Nylander, T.; Varga, I. Effects of bulk colloidal stability on adsorption layers of poly(diallyldimethylammonium chloride)/sodium dodecyl sulfate at the air-water interface Studied by Neutron Reflectometry. *J. Phys. Chem. B*. 2011, 115, 15202–15213
- [4] Ábraham, A.; Campbell, R. A.; Varga, I. New method to predict the surface tension of complex synthetic and biological polyelectrolyte/surfactant mixtures, *Langmuir*, 2013, 29, 11554–11559