Solutions of surfactant oligomers: a model system for tuning foam stability by the surfactant structure

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We report experiments on aqueous foams made of solutions of oligomers of cationic surfactants. The degree of oligomerization is varied up to 4, and two spacer lengths are used. We have studied both the interfacial dilational and shear rheology, the single thin film properties, the foamability of the solutions, as well as the aging and the mechanical properties of the 3D foams. We have found clear differences between the oligomeric systems at all length scales. We then discuss the correlations between the properties at the different length scales and see how the macroscopic features depend on the molecular structure. This work first allows us to determine the relevance of each measurement; in that respect, it stresses the important role of the timescales, and the need to monitor the liquid fraction and bubble size in order to perform correct comparisons. Secondly, this work provides information on how one could optimize foaming properties with oligomers, and the balance between the degree of oligomerization and spacer length.

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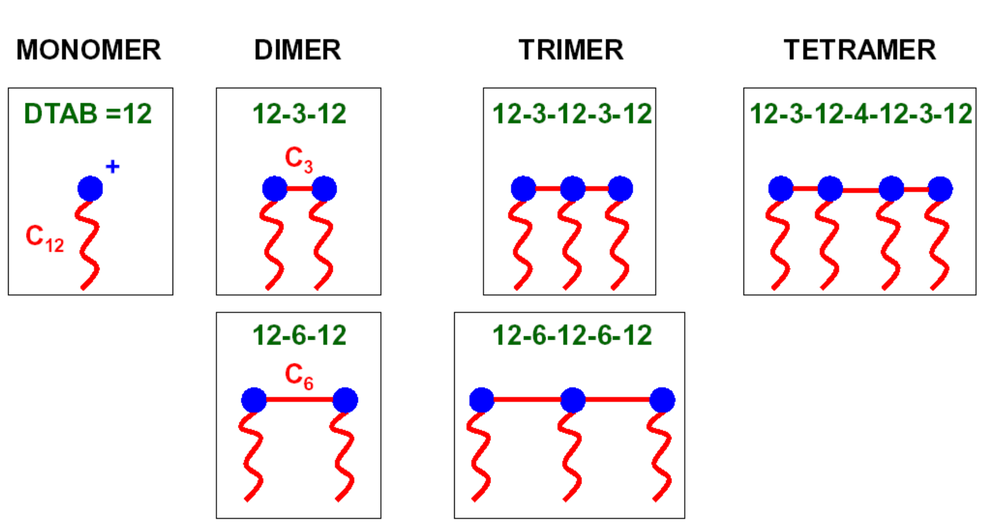
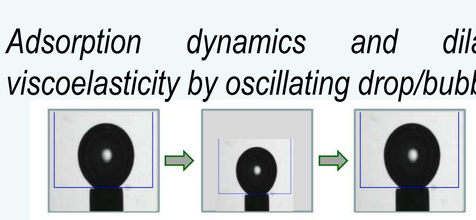
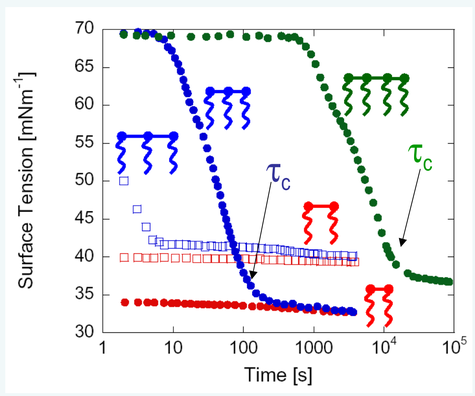
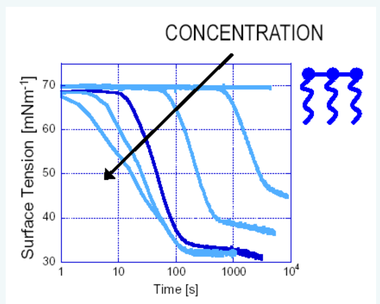


Interfacial studies :

Adsorption dynamics and dilational viscoelasticity by oscillating drop/bubble :



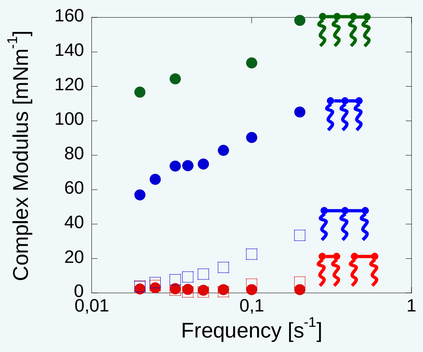


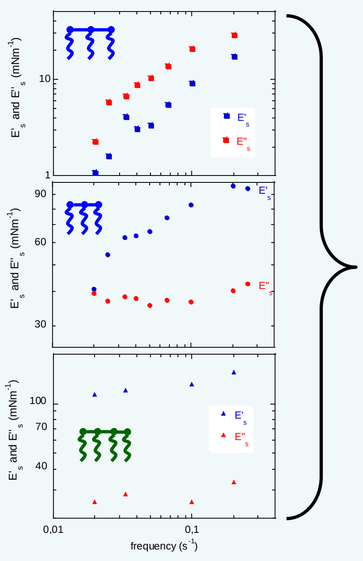


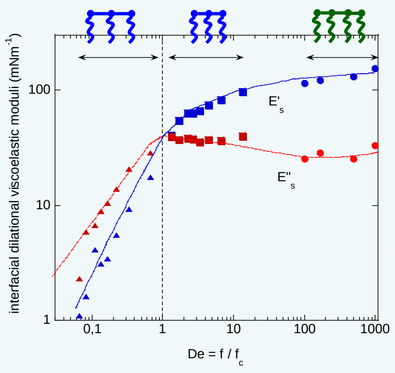
Slow equilibration and low value of surface tension rare in surfactant systems

2D shear viscoelasticity : no signal…

2D dilational viscoelasticity :





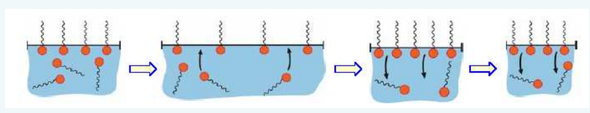


A master curve when normalizing data by $f_c = 1/t_c$

« frequency/molecule superposition » method

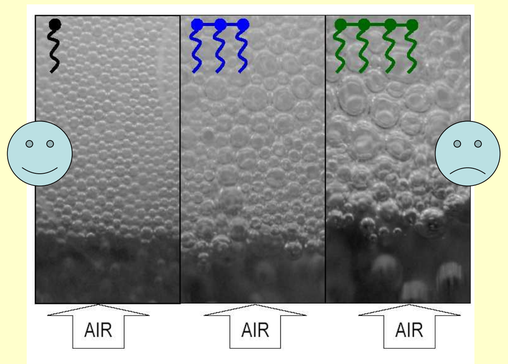
De : f / f_c : Deborah number

All the viscoelastic properties are qualitatively similar and solely controlled by interface/bulk exchange



foam studies :

Comparing foamability for fixed gas injection parameters :

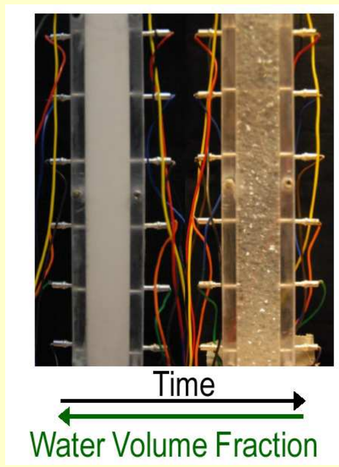


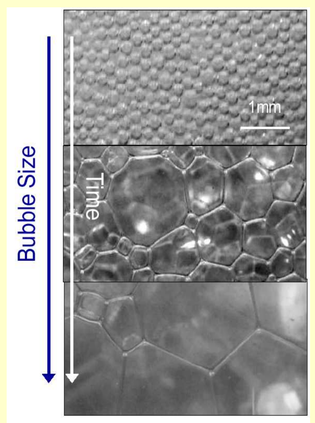
Almost no foam for the tetramer

Consistent with adsorption times

Foaming process is crucial

Stability in time ? monitoring aging

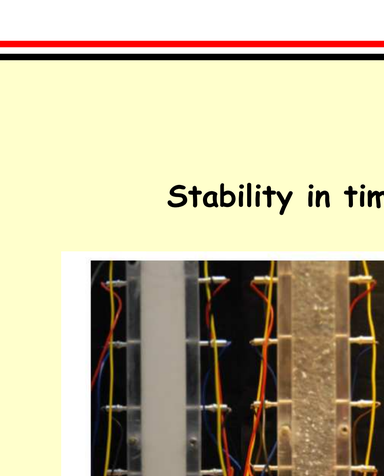


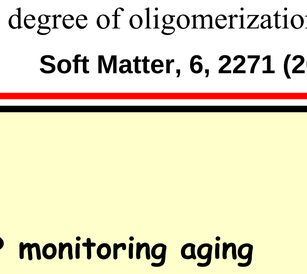


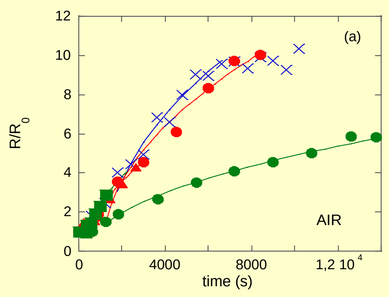
For the short-spacer trimer : anomalously slow drainage

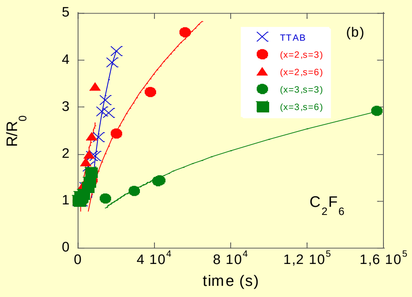
For the long-spacer trimer : Film ruptures occurs

Cannot be explained by existing models





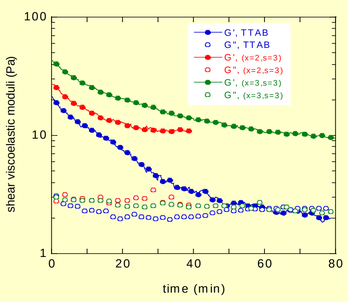




Much slower coarsening for : (with short spacer)

Consistent with interfacial results ? liquid fraction is not the same…

Significant differences in aging dynamics resulting from the molecular structure !



Higher bulk foam elasticity for the trimer (with short spacer)

Consistent with interfacial results

- Oligomeric surfactants : model interfacial system
- Interfacial properties can be re-scaled by $f_c = 1/t_c$
- In practice, a balance between foaming process and viscoelasticity :
  -good foamability requires the lowest t_c
  -high stability requires the lowest f_c
  -but $f_c = 1 / t_c$
  ↓
  an optimal situation:
  here, for the short-spacer trimer
- Drainage is finally more anomalous, than coarsening
- Bulk properties are also important: different types of micelles
- Warning : comparisons can be done only if all foam parameters are monitored and identical