Surfactant foams doped with laponite: unusual behaviors induced by aging and confinement

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We report results on foams stabilized by surfactant (Sodium Dodecyl Sulfate) and containing clay particles (laponite). We have studied how these foams age with time (drainage and coarsening) and their rheological properties. Due to the doping with laponite, which provides an additional time evolution of the foaming fluid itself, unusual behaviors are observed: especially, drainage arrest and re-start and enhanced elasticity are observed as a function of time. These results can be interpreted in terms of both confinement of the laponite inside the foam liquid channels, and competition between the laponite aging and the one of the foam (controlled by its own physical parameters). By playing with these foam parameters and those of the bulk solution containing laponite, we can control the time evolution and these non-monotonous features. Qualitatively, it is found that time, laponite concentration and confinement have all the same effect, enhancing the jamming of the interstitial fluid inside the foam.

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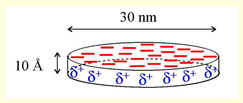
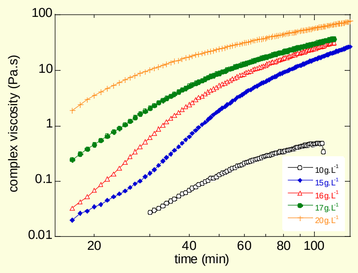
Synthetic clay particles : laponite



With SDS C_{sds}=4g/L

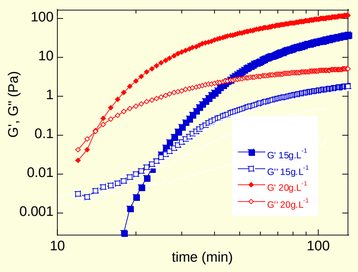
C_{lap}=10 to 20 g/L



A foaming fluid which ages…

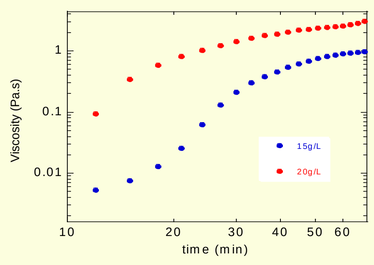
-viscosity increases with time

-viscosity increases with concentration



-a yield stress develops, depending on the solution age and concentration

Also, observed at constant shear rate ($1s^{-1}$) :

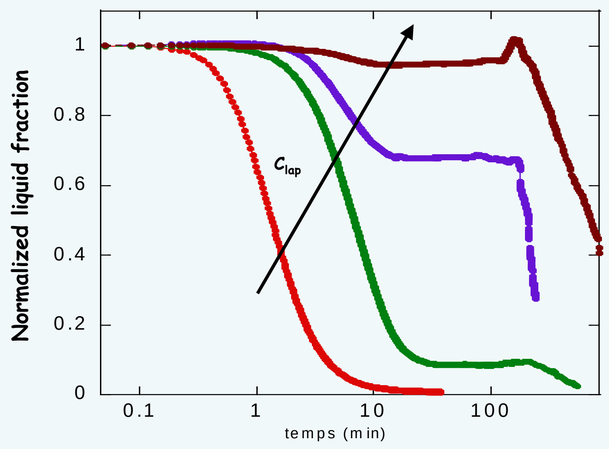


How this aging of the solution is coupled with the aging of the foam ?

Foam results :

For initial bubble diameter D_0 = 100 µm

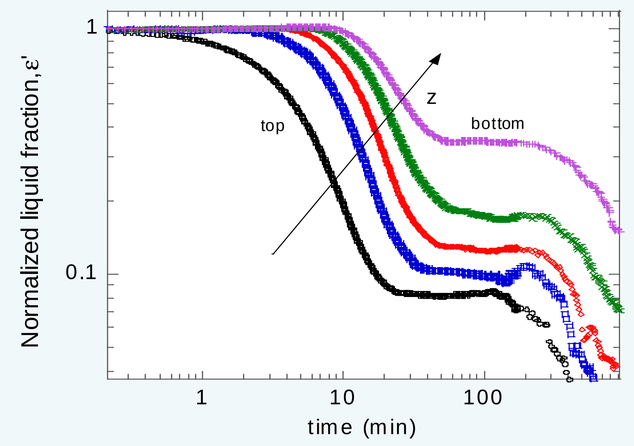
drainage at a fixed position, for various laponite concentrations:



- drainage can stop
- then it re-starts
- Still, at long times : always a final full drainage
- These effects vanish for larger D_0

non-usual and non-monotonous behavior !

At a fixed concentration, as a function of the position:

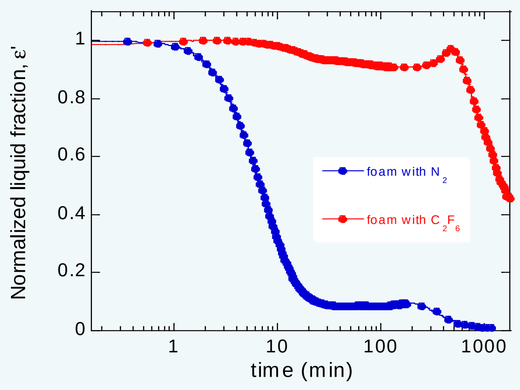


- Same effects as for the concentration
- z – variations, downwards
- ↔ longer foam ages

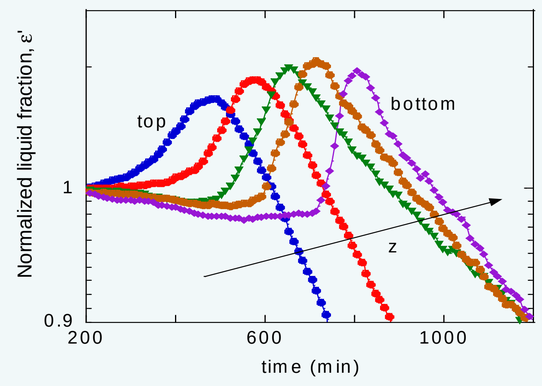
- Strong effect of the gas :

With N_2 : coarsening simultaneous to drainage, D increases with time

With C_2F_6 : no coarsening , D= cst

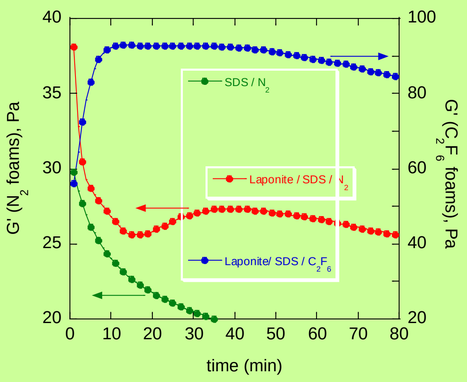


- A bump, often seen just before the final drainage
- It propagates downwards



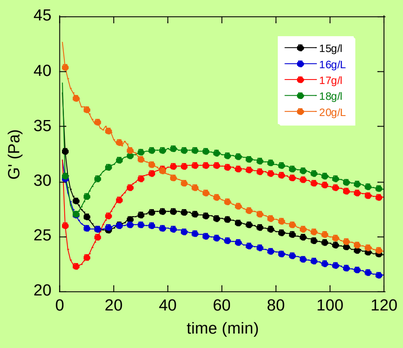
rheological properties :

performing small oscillations at constant amplitude and frequency



non-monotonous behavior !

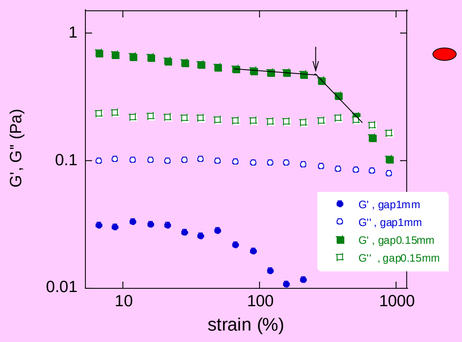
Different dynamics depending on the chemistry and concentrations



Origin of these laponite-induced features ?

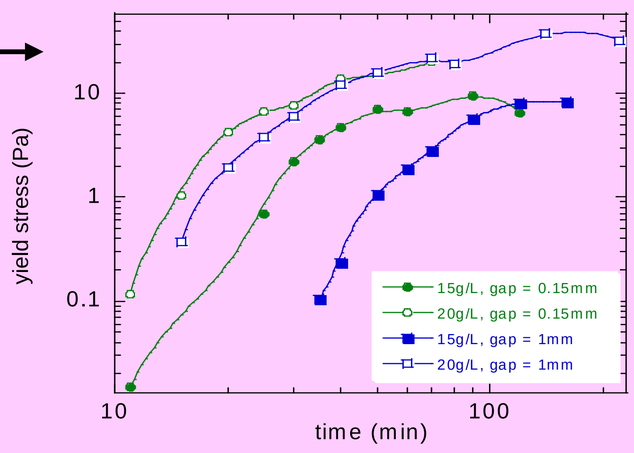
foam aging + laponite aging + confinement

blockage → gravitational stress σ_g < yield stress σ_y ? Is it possible ?



- Solution yield stress σ_y measured by oscillatory measurements : effect of the confinement…

yield stress σ_y depends on : age, concentration and confinement



- Typical σ_g within the foam ? from fluid velocity, one gets 1 to 10 Pa

- The increasing yield stress can indeed become bigger than the gravitational one : jamming
- time, laponite concentration and confinement are similar, blocking the fluid flow, by providing a yield stress
- With such ingredients, one can explain all the observed features

re-start → coarsening: de-confinement

The coarsening still proceeds and irreversibly increases the Plateau borders sections : σ_g can become again > σ_y

The observed bump corresponds to a fluid pulse obtained when the fluid gets unjammed.