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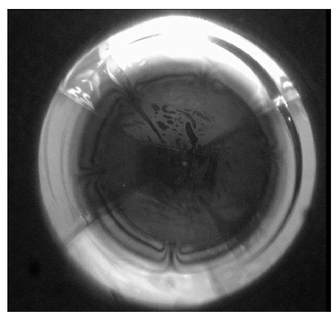
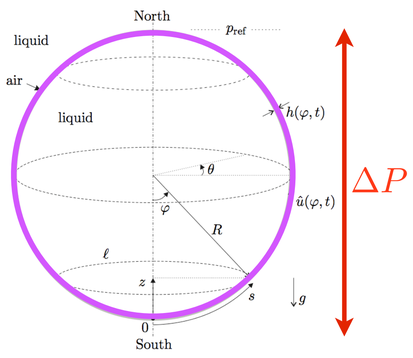
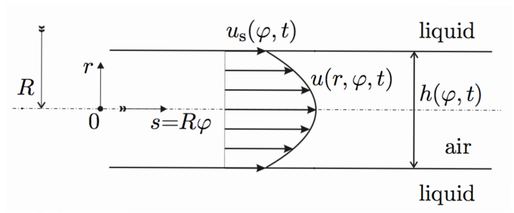
antibubble: influence of the surface viscosity

Introduction

An antibubble is composed by a thin air spherical shell (<3µm) immersed in a liquid mixture.







Air flow boundary conditions: slipping or not slipping?

It has been shown [1] that the lifetime of an antibubble is driven by the drainage of the air from the bottom to the top due to the hydrostatic pressure gradient. The air flow was considered to be Poiseuille-like [1,2] in order to estimate the lifetime of an antibubble.

In this work, we consider the influence of the **nature** of the surfactant on the antibubble lifetime.

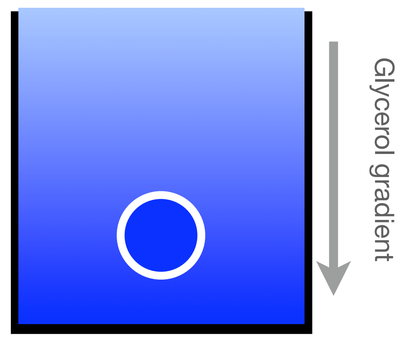
Experimental details

Liquid mixture description

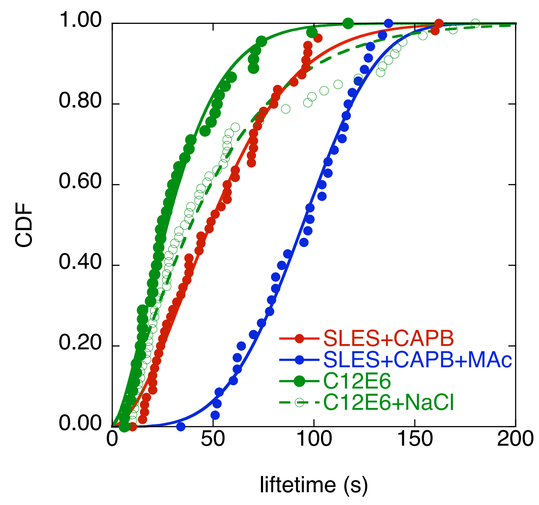
Name	Viscosity (mPa.s)	Surface modulus (mN/m)
SLES+CAPB [3]	0.9	4.2
SLES+CAPB+MAc [3]	0.91	305
C12E6 (10 CMC)	1	unknown
C12E6 + NaCl (0.2M)	1	unknown

SLES: *Sodium Lauryl-dioxyEthylene Sulfate*;
CAPB: *CocoAmidoPropyl Betaine*;
MAc:*Myristic Acid*

A small quantity of glycerol is added to the antibubble to surpass the buoyancy. A glycerol gradient of concentration is set in the vessel in order to stop the antibubble at a given depth under the surface.



Experimental results



Cumulative Distribution Function of the antibubble lifetimes

Weibull distribution

$$F(\tau) = 1 - \exp(-(\tau/\lambda)^h)$$

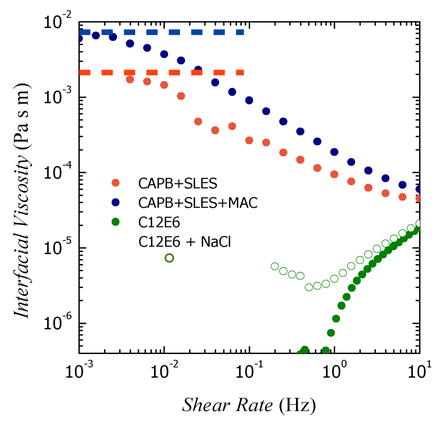
h=1, the distribution is exponential (no memory effect)
h>1, the probability of popping increases with the time

Name	$\bar{\tau}$ (s)	σ (s)	h	*distr.*	$2R$ (mm)	$F(\tau^*)=0.9$
SLES+CAPB	47	33	1.4	exp	12.6±1.6	95
SLES+CAPB +MAc	87	28	3.4	gauss	12.0±1.2	124
C12E6	27	27	1.0	exp	12.4±1.1	62
C12E6+NaCl	45	47	0.96	exp	12.3±1.8	104

The durations corresponding to F=0.9 are used to evaluate the surface viscosity (dilatational of shear)

Surface viscosity and model

Surface viscosity: **DIRECT** measurements using Anton Paar MCR



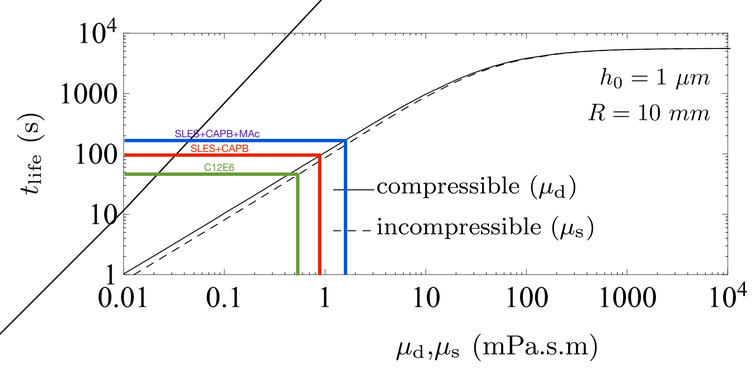
The asymptotical values for the surface viscosity μ_s
SLES+CAPB: ~3 mPa.s.m
SLES+CAPB+MAc: ~7 mPa.s.m

The surface viscosity of the C12E6 is below the apparatus resolution.

The NaCl salt seems to increase the surface viscosity.

Surface viscosity: **INDIRECT** measurements using antibubbles

see B. Scheid O-18, Tuesday at 11:00



Two scenarii have to be envisaged according to surfactant layer properties:

	Compressible	Incompressible
Viscous surface	dilatational μ_d	shear μ_s

According to the lifetime found experimentally, the viscosity can be estimated

SLES+CAPB	incompressible (ta<<tc)	μ_s ~ 0.9 mPa.s.m
SLES+CAPB+MAc	incompressible (ta<<tc)	μ_s~ 1.8 mPa.s.m
C12E6	compressible (ta~tc)	μ_d ~ 0.5 mPa.s.m

The ratio between the surface viscosities of SLES+CAPB systems is compatible with the direct measurements of the surface viscosities.

Conclusion

The nature of the surfactant influences the lifetime of the antibubble. The model based on the influence of the surface viscosity on the lifetime allows to explain the difference of antibubble lifetime between SLES+CAPB and SLES+CAPB+MAc. However, the lifetime obtained for the C12E6 measurement remains unexplained as the distribution of the lifetime changes compared to SLES+CAPB systems and the surface viscosities are very low.

Acknowledgement

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References

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[4] Additional movies at http://www.youtube.com/stephanedorbo