

Effect of surfactants on drop coalescence

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Introduction

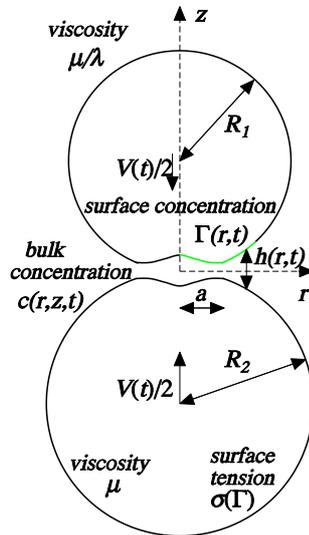
Most practically interesting dispersions contain surface-active materials, either by accident or by design. Surfactants can strongly affect coalescence and especially the film drainage by immobilizing the interfaces.

Objectives

- develop a model for numerical simulation of film drainage in the presence of surfactants;
- investigate the influence of surfactants on film drainage and rupture.

Film drainage model hydrodynamic part

- $a \ll R_{eq}$, where:
 $R_{eq}^{-1} = \frac{1}{2}(R_1^{-1} + R_2^{-1})$
- $h \ll a$, hence: lubrication approximations in the film solved by FDM;
- Stokes equations in the drop phase solved by BIM.



surfactant transport

- surface equation of state:
 $\sigma = \sigma_s - \Gamma R_G T$;
- isothermal adsorption:
 $\Gamma(r, t) = k \cdot c(r, z, t)|_{interface}$
- convection-diffusion of the surface concentration $\Gamma(r, t)$ on the interfaces solved by FDM;
- convection-diffusion of the bulk concentration $c(r, z, t)$ in the film solved by FDM.

boundary conditions

- continuity of the velocity and tangential stress, taking into account Marangoni effect - $\partial\sigma/\partial r$;
- continuity of the normal stress, neglecting the normal stress variation in the drop;
- constant interaction force: $F = 2\pi a^2 \sigma / R_{eq}$.

Results

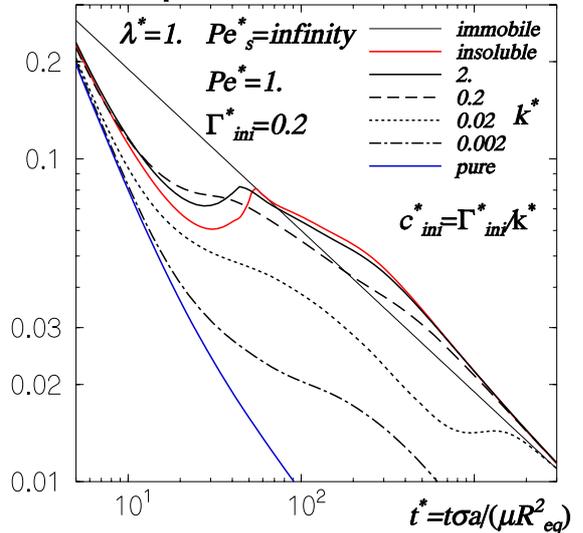
dimensionless groups

viscosity ratio $\lambda^* = \lambda a / R_{eq}$;
initial surface concentration $\Gamma_{ini}^* = \Gamma_{ini} R_G T R_{eq}^2 / (\sigma_s a^2)$;
surface Peclet number $Pe_s^* = \sigma_s a^3 / (D_s R_{eq}^2 \mu)$;
initial bulk concentration $c_{ini}^* = c_{ini} R_G T R_{eq} / \sigma_s$;
bulk Peclet number $Pe^* = \sigma_s a^5 / (D R_{eq}^4 \mu)$;
adsorption isotherm parameter $k^* = k R_{eq} / a^2$.

film drainage and minimal film thickness

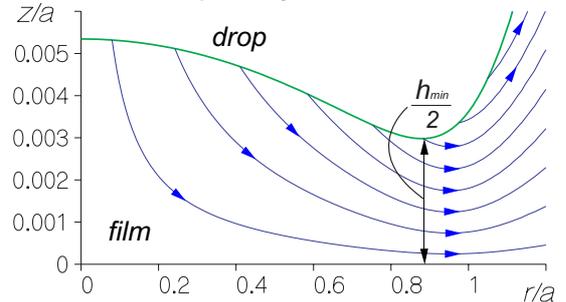
- evolution of the minimal film thickness h_{min}

$$h_{min}^* = h_{min} R_{eq} / a^2$$

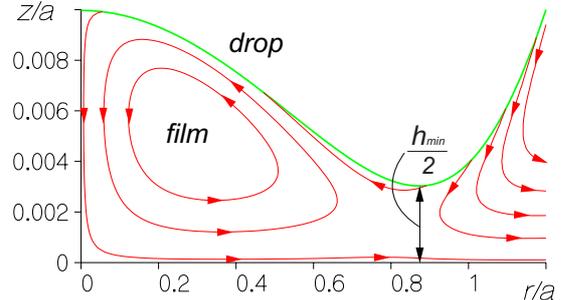


- streamlines for $R_{eq}/a = 10$.

- in the pure system at $t^* = 13$;



- in the insoluble case at $t^* = 130$.



- The following effects were encountered:

- oscillatory behaviour of the minimal film thickness;
- spontaneous dimple growth;
- reversed flow in the film (anti-drainage).

Conclusion

- The main effect of the surfactants on film drainage is the immobilization of the interfaces, which can significantly slow down the film drainage.