Surfactant transport onto a foam lamella in the presence surface viscous stress

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The transport of surfactant onto a foam lamella in a foam fractionation column with reflux has been simulated mathematically. Insoluble surfactant is assumed since such surfactants potentially derive more benefit from a reflux system. The transport of surfactant on the surface of a lamella is governed by the film drainage towards the Plateau border, the Marangoni effect in the direction towards the centre of the film and possibly also the surface viscous effect that balances the resultant of the other forces. The desirable condition is when the Marangoni effect dominates the film drainage, where surfactant accumulates on the surface of the lamella. The surface viscous effect takes place when there is movement on the surface and it slows down the velocity on the surface. In this study, a case without film drainage is examined as a benchmark for more complicated systems. A mathematical model of the surface velocity has been developed and results in a differential equation for surface velocity which is solved using the finite difference method. The calculated surface velocity is used to compute the evolution of surfactant surface concentration using a material point method. The model is verified using analytical solutions for the special case where the surface viscous effect is very small. The numerical model is verified using the analytical solution in the special case where the gradient of the logarithm of surface concentration is linear in space. The Green's function solution of the differential equation is also used to verify the numerical model. The result of the simulation in the presence of surface viscosity is compared with the simulation result in the absence of surface viscosity. It was found that the surface velocity slows down markedly near the Plateau border due to the effect of surface viscous stress. At any given time, the larger the surface viscosity is the lower the surfactant surface concentration. It was also found that the characteristic time scale for moving surfactant onto the film is smaller with the shorter film length.