An accurate finite element solution of interface flows with surfactants

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A moving mesh finite element scheme using the arbitrary Lagrangian Eulerian approach is presented for computation of interface flows with soluble/insoluble surfactants. The fluid flow is governed by the time dependent incompressible Navier-Stokes equations with appropriate boundary conditions. The surfactant concentration over the deforming interface is described by a scalar convection-diffusion equation with a source like term to account for the local changes in the interface area. The effect of surfactants on the flow dynamics is incorporated through the surface/interface tension, which may be a linear or non-linear function of surfactant concentration. In addition, if the surfactant is soluble, the surfactant concentration in the bulk phase is described by another scalar convection-diffusion equation with an appropriate boundary condition for the surfactant mass transfer between the interface and the bulk phase.

The second order implicit fractional step ϑ scheme is used for temporal discretisation of these equations. The velocity is spatially discretised by the continuous, piecewise quadratics enriched by a cell bubble functions and the pressure is spatially discretised by the discontinuous, piecewise linear functions. The surfactant concentration in the bulk phase and on the interface is spatially discretised by the continuous, piecewise quadratics functions. To approximate the curvature over the interface, the Laplace-Beltrami operator technique is used. A number of computations are performed to show the accuracy and the robustness of the numerical scheme. An excellent mass conservation is obtained for the fluid in each phase and for the surfactants.

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