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Bubble suspension in yield-stress fluids

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ABSTRACT

Gas emissions from tailings ponds is one of the environmental challenges of oil sands production. In a stratified pond, the fine fluid tailings (FFT) forms a layer which does not appear to consolidate significantly over timescales of 10-100 years. The bulk rheology of this layer exhibits yield stress [1]. Hence, here we study the conditions for a bubble to be statically buoyant in a yield-stress fluid without any motion. The key parameter is the yield number $Y = \tau_y/(\Delta\rho g l)$, which represents the ratio of the yield stress to the buoyancy stress (l is the volumetric radius of the bubble). The goal is to compute the critical yield number Y_c for a single bubble with different shapes for a wide range of surface tensions: if $Y < Y_c$ then the bubble rises and if $Y \geq Y_c$ then the yield stress suppresses the flow and makes the bubble static.

We previously demonstrated that particles which are close enough can form clusters in a yield-stress fluid and move together which can tremendously increase Y_c in a suspension [2]. Here, the aim is to shed light on how the bubbles feel their neighbors and interact, and hence to evaluate Y_c for a suspension (or cloud) of bubbles as a function of volume fraction ϕ. We perform 2D computations in a full periodic box with randomized position of the monodispersed circular bubbles. A large number of realizations are investigated to obtain statistically converged results. The results show that $Y_c(\phi)$ is a linear function for $\phi < 20\%$.

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