SPREADING OF A DROPLET ON A ELASTOVISCOPLASTIC SUBSTRATE

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ABSTRACT

Wetting phenomena, which involve spreading of liquids on soft materials are abundant in technological, environmental and biomedical applications ranging from drug delivery, to wetting and coating of leaves or textiles, to cell 3D printing, to the spreading of oil slicks, etc. Such multiphase systems typically consist of three phases (i.e., liquid droplet, compliant substrate and air), one of which may often exhibit complex Non-Newtonian behavior. In the present work, we examine the spreading dynamics of a droplet on top of an immiscible elastoviscoplastic (EVP) material. These materials behave as perfect elastic solids with an elastic modulus G under small stresses. However, they flow like viscoelastic liquids with a relaxation time λ beyond a critical stress τ_y, also known as the yield stress of the material[1]. Here, we simulate this three-phase system employing the rheoMultiFluidInterFoam solver[3], which has been recently developed by our group based on the OpenFOAM framework. To account for the elastoviscoplasticity of the material we employ Saramito's model [2]. We perform a detailed numerical study to investigate the effect of yield stress and developed viscoelastic stresses on the dynamics and extent of droplet spreading.

Our results indicate that droplet spreading over an EVP substrate can be stopped if the capillary forces are not strong enough to overcome the yield stress of the material. This effect cannot be predicted using simpler regularized generalized Newtonian constitutive (e.g. Herschel-Bulkley-Papanastasiou model) which describe the unyielded material as a highly viscous fluid. Furthermore, we observe that as the material's elasticity increases, its yielding occurs at later times. Lastly, we examine the effects of surface tension and the spreading parameter, and the thickness of the EVP substrate.

KEYWORDS: Elastoviscoplastic, Spreading lens, Saramito's model, OpenFOAM

REFERENCES

[1] D. Fraggedakis, Y. Dimakopoulos, and J. Tsamopoulos, 2016, *Yielding the yield-stress analysis: a study focused on the effects of elasticity on the settling of a single spherical particle in simple yield-stress fluids*, The Royal Society of Chemistry, vol. 12, pp. 5378–5401.

[2] P. Saramito, 2009, *A new elastoviscoplastic model based on the Herschel–Bulkley viscoplastic model*, Non-Newtonian Fluid Mechanics, vol. 158, pp. 154–161.

[3] C. Dritselis and G. Karapetsas "Open-source finite volume solvers for multiphase (n-phase) flows involving either Newtonian or non-Newtonian complex fluid" Computers and Fluids 245 (2022) 105590