Abstract Submitted
for the DFD17 Meeting of
The American Physical Society

Low-order models for the drag reduction of surfactant-contaminated superhydrophobic surfaces J. LANDEL, University of Manchester, F. PEAUDECERF, R. GOLDSTEIN, University of Cambridge, F. TEMPRANO-COLETO, F. GIBOU, P. LUZZATTO-FEGIZ, UC Santa Barbara
— In a recent study, Peaudecerf et al. (PNAS 2017) showed that surfactant can decrease the drag-reduction performance of superhydrophobic surfaces (SHS). As SHS could have a large impact in reducing energy utilisation for many internal and external flow applications, it is important to understand and predict how surfactant-Marangoni stresses affect the flow over SHS. We present a semi-analytical model solving Stokes flow over an SHS, coupled with surfactant transport in the bulk and at the interface using modified Frumkin kinetics. We consider both a Poiseuille flow in a two-dimensional channel with a periodic array of plastrons on one side and a two-dimensional shear flow over a flat solid surface with a periodic array of plastrons. We find that at low surfactant concentration this complex nine non-dimensional parameter model can be reduced to eight parameters by combining the Marangoni number and the normalised concentration. At steady state, we obtain a prediction of the Marangoni shear stress due to the concentration gradient of the surfactant adsorb onto the plastron, assuming a uniform shear stress along the plastron. We compare the model with finite-element numerical simulations of the full transport problem. Good agreement is found for a large range of geometries, flow conditions and surfactant properties.

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Date submitted: 01 Aug 2017 Electronic form version 1.4