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Vesicle Dynamics in Large Amplitude Oscillatory Extension, Simulations and Microfluidic Experiments CHARLIE LIN, Purdue University, DINESH KUMAR, CHANNING RITCHER, University of Illinois at Urbana-Champaign, SHIYAN WANG, Purdue University, CHARLES SCHROEDER, University of Illinois at Urbana-Champaign, VIVEK NARSIMHAN, Purdue University
— While the behavior of fluid vesicles in steady flows have been studied extensively, how time-dependent oscillatory flows impact the shape dynamics of vesicles is not understood. We investigate the non-linear extension and compression dynamics of vesicles in large amplitude oscillatory extensional (LAOE) flows using a combination of microfluidic experiments and boundary integral (BI) simulations. Our results characterize the transient membrane deformations, dynamical regimes, and stress response in LAOE in terms of reduced volume (vesicle's asphericity), capillary number (Ca, dimensionless flow-strength), and Deborah number (De, dimensionless flow-frequency). Single vesicle experiments are compared to BI simulations without thermal fluctuations, and agreement is found across a wide range of parameters. We establish three dynamical regimes based on the vesicle deformation: the pulsating, reorienting, and symmetrical regimes. The distinct dynamics observed in each regime result from the competition between the flow frequency, flow time scale and membrane deformation timescale. We have additionally observed the relation between average stress and strain rate is highly nonlinear. The consequences of such rheology and the dynamical regimes will be discussed in this talk.

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