Extreme deformation of giant unilamellar vesicles in a complex shear flow

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Giant unilamellar vesicles are useful model systems to study the dynamics of some cellular processes and transport phenomena, including viral infection, endocytosis, exocytosis, and cell fusion. In addition, vesicles find applications as vehicles for drug delivery and in the food industry. The response of vesicles to flow and deformation is central to these applications as it affects the non-Newtonian rheology of vesicle suspensions.

The dynamics of vesicles under small deformation in simple shear flow is relatively well understood. Complex behaviors are observed, such as tumbling, breathing, and tank-treading, depending on the viscosity contrast between interior and exterior fluid, excess area, membrane viscosity, and bending modulus [1-3]. On the contrary, phenomena upon extreme deformation are still poorly understood. These include shear-induced pore formation, membrane rupture, and vesicle lysis [4], which can be exploited in biomedical applications provided that they can be triggered in a controlled fashion.

We study the behavior of giant unilamellar vesicles in a complex microscale shear flow in an acoustofluidic setup. We explore the effect of lipid composition and resulting membrane properties (area expansion and bending modulus, membrane viscosity) on mechanisms of pore formation, rupture and lysis. Failure events are visualized using a fluorescence-based leakage assay.

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