Measurements of extensional viscosities of suspensions of motile microbes

Amarin G. McDonnell[1], Sharadwata Pan[2], David Hill[3], Michael K Danquah[3], James R. Friend[1], Leslie Y. Yeo[1] and Ranganathan Prabhakar[1]

[1]*Department of Mechanical and Aerospace Engineering, Monash University, Australia*[*]

[2]*Department of Chemical Engineering, IITB-Monash Research Academy, IIT Bombay, India*

[3]*Department of Chemical Engineering, Monash University, Australia*

The effective viscosity of an active suspension of rod-like self-propelled particles in either shear or extensional flows is predicted to depend on whether particles push fluid away from their ends, or draw it inward. We study extensional flows of low-viscosity aqueous microbial suspensions with a novel capillary-breakup device that uses surface acoustic waves to create observable liquid bridges rapidly from microliter-sized sessile droplets. The dynamics of mid-filament necking of the liq- uid bridges of both live- and dead-cell suspensions are qualitatively similar to those observed for (Newtonian) standard glycerol-water mixtures. This permits extraction of effective extensional viscosities of cell suspensions by comparison with theoretical predictions of capillary breakup for Newtonian liquid bridges at arbitrary Ohnesorge number. In line with recent predictions for ac- tive suspensions, we observe that *Escherichia coli* "pusher" suspensions have a lower extensional viscosity than the corresponding dead-cell suspensions, while in *Dunaliella tertiolecta* "puller" sus- pensions, the behaviour is reversed. The observed concentration-dependence of active suspension viscosities is correlated with swimming motility characterized in terms of mean swimming speeds and diffusivities obtained through cell-tracking image-analysis of static suspension samples.

[*]Electronic address: