Stabilizing Toroidal Droplets

Ekapop Pairam, Greg Douthit and Alberto Fernandez-Nieves

Introduction
Toroidal droplets made up of Newtonian liquid inside another immiscible Newtonian liquid are unstable and will undergo a transformation into spherical droplets in order to minimize the interfacial surface area. The route of transformation will either be breaking ala Rayleigh-Plateau or growing fatter until the inner of the tube coalesces into a single spherical droplet depending on the aspect ratio of the torus. In order to prevent these break up we replaced the outer phase with a viscoelastic fluid which possesses yield stress which acts against the instability causes by interfacial surface tension.

Observations
After the generation of toroidal droplets inside a viscoelastic fluid we observed that the toroidal droplet will break if its tube radius is under the critical tube radius and will collapse if its inner radius is under the critical inner radius. These values are constant and unique for each yield stress.

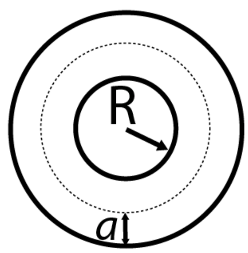

Figure 1: Schematic diagram of toroidal droplet viewing from the top where a is the tube radius and R is the inner radius.

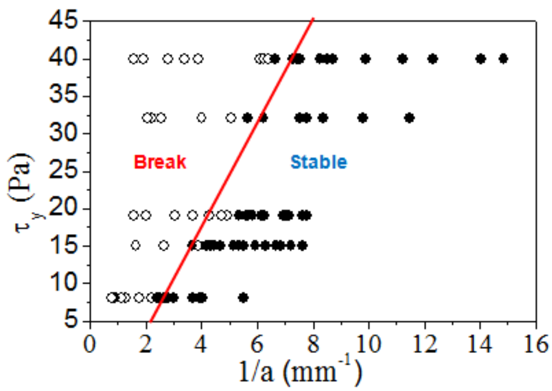

Figure 2: Diagram showing that the critical tube radius is inversely proportional to the yield stress of the viscoelastic medium.

Benefits

Capitalizing on the stabilizing property of the outer fluid we can stabilize droplet with even more handles. We can also control the size of the droplet generated by tuning the yield stress of the outer viscoelastic fluid.

Figure 3: Stable droplets of multiple handles.

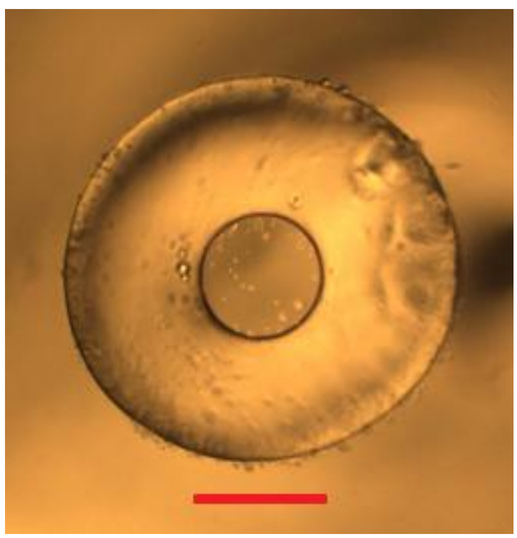

Figure 4: Stable droplets of about 1mm in size. The red scale bar represent 300µm.

Useful Reference: E. Pairam and A. Ferna´ndez-Nieves, *Generation and Stability of Toroidal Droplets in a Viscous Liquid*, Physical Review Letters, 102, 234501 (2009).

Contact Information:

Ekapop Pairam
Office: Boggs Building, Room B-55A

Email address: *gth675d [at] mail.gatech.edu*
Phone: 404-385-3682