The Rayleigh-Plateau Instability of biopolymer solutions
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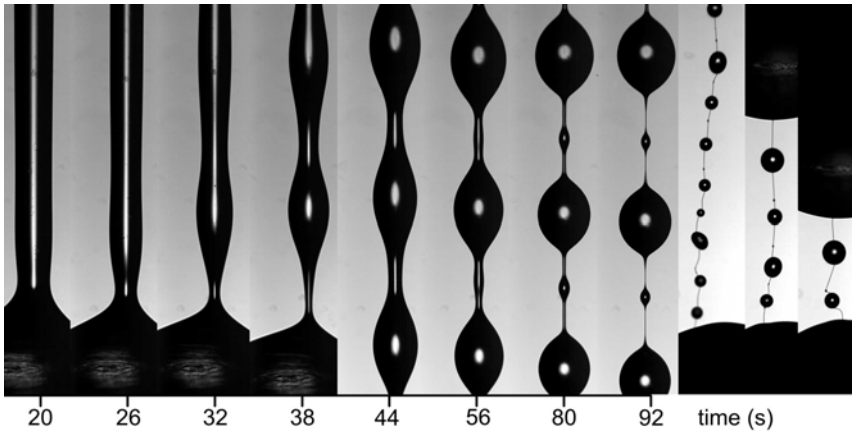
ABSTRACT

Most Biofluids in our body contain a large amount of macromolecules. Macromolecules or polymers are known to oppose elongational flow much stronger than shear flow. An illustrative example of elongational flow is given by a thinning capillary bridge. An everyday example is a droplet of saliva that is placed between two fingers. Due to the presence of the macromolecules, the finite time singularity of the pinch off process is suppressed and an almost uniformly cylindrical thread is formed. Capillary thinning is one of the few experiments that allow the determination of the elongational viscosity. In the last stages of thinning, when polymers have become fully stretched, the filament becomes prone to several instabilities, e.g. a “breathing” instability, originating from the edge of the filament, and a sinusoidal instability in the interior, which ultimately gives rise to a Rayleigh Plateau instability followed by a blistering pattern of beads on the filament. High speed video observation with sub-difractional spatial resolution and micro-PIV measurements indicate the existence of irregular flow fields. For sufficiently high polymer concentrations, the filament eventually separates out into a solid phase of entangled polymers, connected by fluid beads. A solid polymer fiber of about 100 nanometer thickness remains, which is essentially permanent.
For another type of a biopolymer, a DNA solution, we use the well characterized physical properties of this electrolytic macromolecule to both change its flexibility by adding salt ions to the solvent and relate the flexibility parameter with both the elongational viscosity and its capability of reducing drag in inertial turbulence.



The formation of the beads-on-a-string structure during the capillary break-up of a droplet of saliva. The time elapsed from the formation of the cylindrical filament is indicated. The filament remained stable for minutes and final rupture has been initiated by agitating the system. This is shown in the three photos on the right that show the stiffness of the polymeric fiber that is formed between the remaining droplets.

REFERENCES

R. Sattler, J. Eggers, C. Wagner Blistering Pattern and Formation of Nanofibers in Capillary thinning of Polymer Solutions *Phys. Rev. Lett.* **100**, 164502 (2008).