

the density of the bridge (since $\rho_{\text{air}} \approx 0$), χ is the magnetic susceptibility, and H is the magnetic field. The Bond number, and therefore the effective gravitational field, was controlled by varying H .

In recent years workers also have attempted to push the slenderness ratio R in a gravity-free environment beyond the theoretical Rayleigh limit of π . This typically has been accomplished by driving the bridge with ultrasound or by application of an axial electric field with an appropriate dielectric mismatch between the bridge and the surrounding medium [9, 10]. Other experiments have been performed on non-Newtonian polymers to extract viscosity versus shear rate information. In these experiments, as the cylindrical polymer bridge is stretched lengthwise, the diameter of the cylinder must be concomitantly reduced so as to keep the volume constant. In such experiments the cylinder is only metastable, and slenderness ratios $R > \pi$ have been achieved [15–17]. These experiments, however, do not examine the stability of non-Newtonian liquid bridges.

2. Experimental

In this paper we report on experiments involving bridges consisting of liquid crystal (LC) in the nematic and smectic A phases. Because of the liquid crystalline order, particularly the orientational order of the nematic and smectic A phases and the translational order of the smectic A phase, one might expect the stability and shape of LC bridges to be somewhat different from their isotropic counterparts. In our experiments we have made several observations:

- (1) The stability of a cylindrical nematic bridge is similar to that of an ordinary isotropic Newtonian fluid, i.e. the maximum slenderness ratio $R \approx \pi$ for Bond number $B = 0$, and less than π for $|B| > 0$.
- (2) Unlike isotropic fluids, cylinders in the smectic A phase may exhibit slenderness ratios considerably larger than π for $B = 0$.
- (3) For $|B| > 0$ cylinders in the smectic A phase remain cylindrical (even those with slenderness ratios in excess of π), with no apparent sagging, until the Bond number exceeds some value B_{deform} . At this point the cylinder begins to sag, but does not break. As the Bond number is further increased by changing the density of the surrounding bath, the bridge eventually collapses when the Bond number increases to a value B_{collapse} .

2.1. The nematic phase

A cylindrical aluminum rod was mounted, facing upward, in a glass 'Plateau' tank. The end of the rod was machined as shown in figure 1 in order to prevent the liquid crystal from running along the side of the rod.

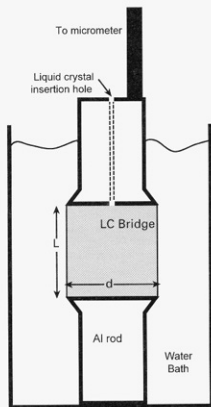


Figure 1. Schematic diagram of experimental set-up. The liquid bridge is formed between two aluminum supports of diameter $d = 0.32$ cm at the tips. The upper support has a hole for injection of liquid crystal, and is attached to a micrometer to facilitate controlled variation of R . The support assembly is in a Plateau tank filled with water.

The diameter of the rod at the tip was $d = 0.32$ cm. A nearly identical rod was mounted on a precision micrometer mount and arranged colinearly and facing downward toward the first rod. Liquid crystal was injected through a small axial hole in the upper rod using a 25-gauge hypodermic needle and butterfly syringe. As the viscosity and other physical parameters of the liquid crystal vary with temperature, the entire assembly, including the tank, was inserted into an aluminum jacket that was electronically temperature controlled to 0.2°C .

In the absence of water, the two rods were first brought close together with a small (~ 0.1 cm) gap between the tips. A small amount of the liquid crystal octylcyanobiphenyl (8CB) at room temperature (in the smectic A phase) was injected into the gap between the tips, so that the liquid crystal completely wetted the ends of the two rods. As the density of the smectic A phase is $\rho_{\text{SmA}} = 0.996$ g cm $^{-3}$ [18], we chose H_2O , whose density is similar, as the density matching fluid. ($\rho_{\text{H}_2\text{O}} = 0.998$ g cm $^{-3}$ at 23°C and 0.994 g cm $^{-3}$ at 36.5°C , the limits of the experiment.) Moreover, D_2O , whose