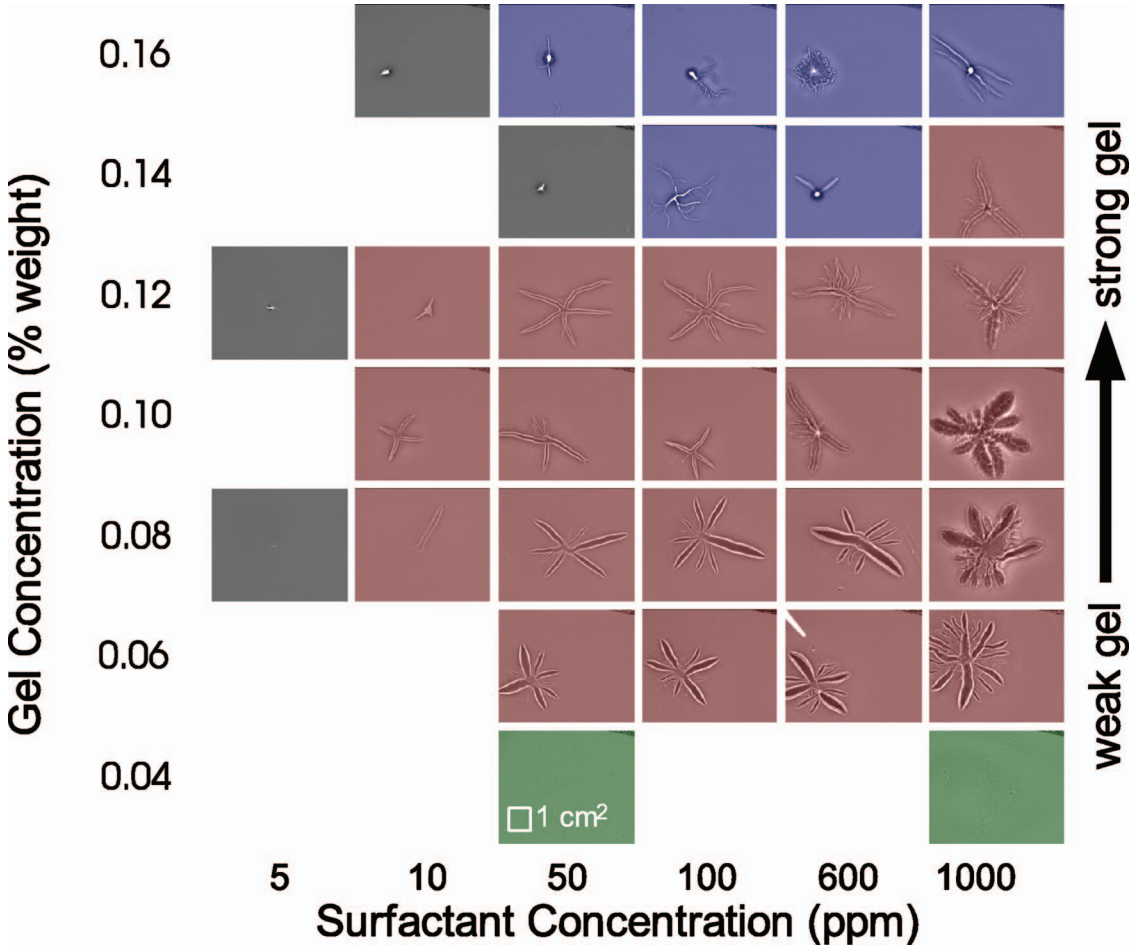

FIG. 1. Phase diagram for droplets of nonionic surfactant solution (Triton X-305) spreading on a viscoelastic agar gel substrate. Red images: starburst instability; blue images: wispy drops; green images: uniform spreading.

Starbursts and wispy drops: Surfactants spreading on gels

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The spreading dynamics of surfactant-laden droplets have been studied for both solid[1] and thin liquid[2] substrates. In general, the presence of a surfactant modifies the contact line dynamics due to the Marangoni effect, which creates a surface tension gradient and thus generates pattern-forming instabilities. To determine the effects of varying substrate mobility from a liquid to a solid, we examine the intermediate case of a viscoelastic substrate. We observe novel instabilities of the surfactant-laden drop influenced by both the substrate fluidity and the surfactant concentration. The experimental apparatus consists of a petri dish containing a gel substrate composed of 0.04% to 0.16% agar (by weight) in deionized water. The droplets are solutions of Triton X-305 (a nonionic surfactant) in deionized water at concentrations from 5 to 1000 parts per million (ppm), released from a micropipette with a droplet size of 5 μL. Figure 1 shows a phase diagram with shadowgraph images as a function of the gel and surfactant concentration. For weak gels, the droplet spreads in a starburst formation, with 3–10 distinct arms (red images). For intermediate gels, the central drop remains but is decorated with thin, branching wisps (blue images). For sufficiently weak gels, the droplet spreads out as upon a liquid, and no central droplet remains (green images). On the strongest gels, the surfactant drops remain circular (not shown). For very low surfactant concentrations (<5 ppm), the behavior resembles that of pure water droplets, and no arm structures are observed.

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