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 ppm, released from a micropipette with a droplet size of 5 mL. Figure 1 shows a phase diagram with shadowgraph images as a function of 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. This work has been supported under NSF Grant DMS-0244498.

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.