Capillary Rise of Yield Stress Fluids

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The capillary rise in a vertical capillary is a well-known phenomenon including Lucas-Washburn-Rideal Equation. The Laplace pressure pulls up the liquid column into the capillary, while bulk (gravitational) and surface (viscous) forces are balancing in the downward direction. From this balance of forces, rising velocity is fast at the beginning and gradually slows down. In this work, this simple phenomenon meets yield stress fluids (YSFs). The key property of YSF is the critical stress for the phase transition from solid-like to liquid-like. Although many experimental works defined velocity profiles of YSF in various geometries, the role of yield stress in capillary phenomena is hardly discussed so far. We used 3 radius capillaries (0.85, 0.56, and 0.18 mm) and 4 different YSFs (2 carbopol and 2 xanthan solutions). Rather than fluid's yield apparent viscosity, the creep (relaxation time scale) dominants rising speed at the beginning. At the later regime, on the other hand, YSF flows in plug flow with slip.