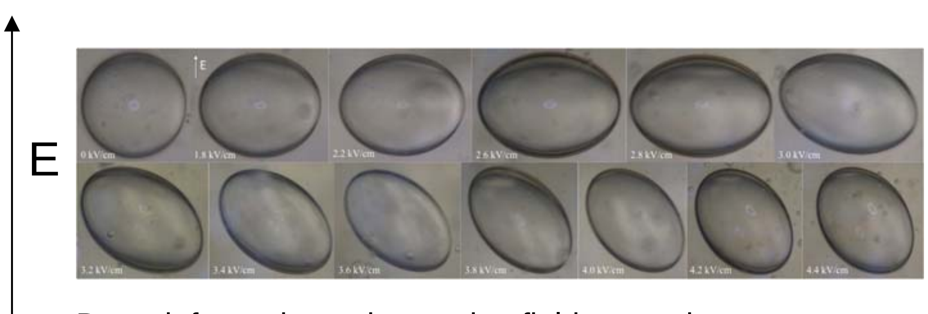
Effect of surfactants on drop electro-hydrodynamics

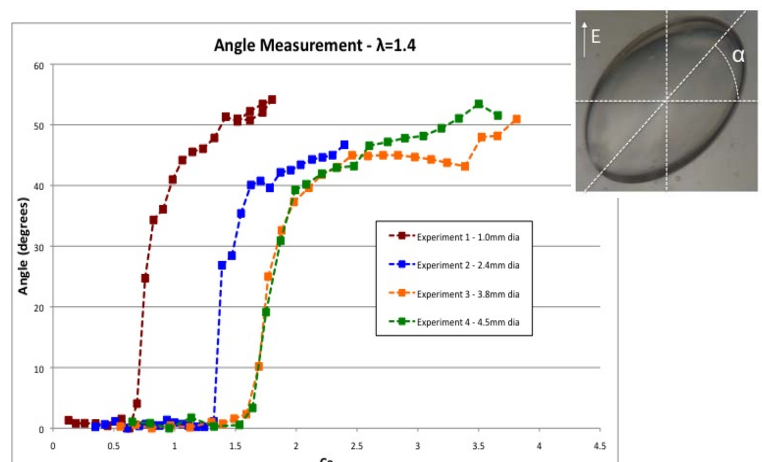
Petia M. Vlahovska, Thayer School of Engineering, Dartmouth College

Goal: understanding of the essential microphysical mechanisms that govern the flow behavior of surfactant-laden emulsions in electric fields

Drop deformation in uniform electric fields is a classic problem. The pioneering work of G.I.Taylor demonstrated that for weakly conducting media, the drop fluid undergoes a toroidal flow and the drop adopts a prolate or oblate spheroidal shape, the flow and shape being axisymmetrically aligned with the applied field. However, recent studies have revealed a nonaxisymmetric rotational mode for drops of lower conductivity than the surrounding medium, similar to the rotation of solid dielectric particles observed by Quincke in the 19th century. We have performed an experimental and theoretical study of this phenomenon in DC fields. The critical electric field, drop inclination angle, and rate of rotation are measured. For small, high viscosity drops, the threshold field strength is well approximated by the Quincke rotation criterion. Reducing the viscosity ratio shifts the onset for rotation to stronger fields. The drop inclination angle increases with field strength. The rotation rate is approximately given by the inverse Maxwell-Wagner polarization time. We also observe a hysteresis in the tilt angle for low-viscosity drops.



Drop deformation at increasing field strength



Inclination angle measured at increasing field strength for different size drops. Critical capillary number increases with drop diameter