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The Influence of Inertia and Charge Relaxation on Electrohydrodynamic Drop Deformation JAVIER LANAUZE, LYNN WALKER, ADITYA KHAIR, Dept. of Chemical Engineering, Carnegie Mellon University — An analytical model is presented for the electrohydrodynamic deformation of a drop in a leaky-dielectric fluid under a uniform electric field, taking into account transient fluid inertia and a finite electrical relaxation time. Capillary forces are assumed to be sufficiently large that the drop only slightly deviates from its equilibrium spherical shape. The temporal droplet deformation is governed by two dimensionless groups: (i) the ratio of capillary to momentum diffusion time scales: an Ohnesorge number Oh; and (ii) the ratio of charge relaxation to momentum diffusion time scales, which we denote by Sa. If charge and momentum relaxation occur quickly compared to interface deformation, $Sa \ll 1$ and $Oh \gg 1$ for the droplet and medium, a monotonic deformation is acquired. In contrast, $Sa > 1$ and $Oh < 1$ for either phase can lead to a non-monotonic deformation. In the latter case, the droplet and medium behave as perfect dielectrics at early times, which always favors an initial prolate deformation. Consequently, for a final oblate deformation, there is a shape transition from prolate to oblate at intermediate times. After the transition there may be an overshoot in the deformation, which is proceeded by an algebraic tail describing the arrival towards steady state.

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