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Relative magnitude of capillary over bulk viscosity resistances for NWP blobs flowing within periodic capillary tubes

Content

We present a parametric study of the dependence of the reduced magnitude of net capillary over bulk viscosity resistances across a solitary blob driven within a periodic axisymmetric capillary tube [1] for different flow conditions. The size of the blob is arbitrary but large enough to preserve continuous contact to the tube walls. Hysteresis is considered by assuming different contact angles of the two N/W menisci (receding and advancing) [2, 3, 4]. The flow analysis implements simple Washburn type approximation for estimating Stokes resistances within the bulk flow and Young-Laplace contact line resistances across the two menisci [5]. The corresponding terms are evaluated from tractable, semi-analytical expressions, for a variety of flow conditions and pairs of receding/advancing contact angles [6]. Effective hysteresis – the result of average, capillarity induced resistances- is manifested as the sum of geometric and physicochemical hysteresis terms. Geometrical hysteresis is associated to the varying pore wall conical geometry at the menisci contact lines; physicochemical hysteresis is associated to the difference between receding and advancing contact angles. The simple case of flow within straight tubes has been also examined and used as a reference.
We show that the relative magnitude of capillary over bulk viscosity resistances depends strongly on the flow rate through the capillary tube. In particular, the calculations show that, for an extended domain of the N/W/PM system parameters and flow conditions, the net capillary pressure drop –due to contact angle hysteresis- is significantly larger that the bulk viscosity induced pressure drop.

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