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Electrohydrodynamic Instability and Enhanced Mixing with Thermal Field and Polymer Addition Modulation

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Abstract : Electrically driven flows (EDF) systems play an important role in fuel cells, electrochemistry, bioseparation technology, fluid pumping, and microswimmers. The core scientific problem is multifield coupling, the further development of which depends on the exploration of nonlinear instabilities, force competing mechanisms, and energy budgets. In our study, two categories of electrostatic force-dominated phenomena, induced charge electrosmosis (ICEO) and ion conduction pumping are investigated while considering polymer rheological characteristics and heat gradients. With finite volume methods, the thermal modulation strategy of ICEO under the thermal buoyancy force is numerically analyzed, and the electroelastic instability turn associated with polymer addition is extended. The results reveal that the thermal buoyancy forces are sufficient to create typical thermogravitational convection in competition with electroconvective modes. Electroelastic instability tends to be promoted by weak electrical forces, and polymers effectively alter the unstable transition routes. Our letter paves the way for improved mixing and heat transmission in microdevices, as well as insights into the non-Newtonian nature of electrohydrodynamic dynamics.

Keywords : non-Newtonian fluid, electroosmotic flow, electrohydrodynamic, viscoelastic liquids, heat transfer
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