| Numerical investigation of heat transfer enhancement in dielectric fluids through electro-thermo-capillary convection | |
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**Abstract:** In this study, a 2D numerical analysis was conducted to investigate electro-thermo-capillary convection in a 2D enclosure filled with a dielectric fluid. The enclosure had a free top surface and was subjected to buoyancy and electrical forces. The study considered a strong unipolar injection of electric charge (C = 10), a mobility number (M = 10), and a Prandtl number (Pr = 10). Calculations were performed for various thermal Rayleigh numbers (Ra) ranging from 5000 to 50,000, Marangoni numbers (Ma) varying from −5000 to 5000 and electric Rayleigh numbers (T) ranging from 100 to 800. The coupled equations governing the electro-thermo-convection problem (Navier-Stokes, energy, charge density transport, and the Maxwell-Gauss equations) were established and solved numerically using the FVM. This study involved mathematical modelling of complex and coupled phenomena, considering viscous, thermal, thermocapillary, and electrical instabilities. The findings showed a significant improvement in heat transfer with higher electrical and thermal Rayleigh numbers. Furthermore, the control of different forces led to an increase in the Nusselt number. Specifically, the application of thermal forces resulted in a 70% increase, while the use of thermocapillary forces led to a remarkable 169% increase. Additionally, electrical forces resulted in an impressive 224% increase. Multi-parameter correlations were established to estimate the Nusselt number as a function of the Marangoni, thermal and electrical Rayleigh numbers.