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Electric Field Induced Instabilities in Viscosity Stratified Miscible Microflows: Transition from Linear Instabilities to Coherent Vortices[1]

SATARUPA DUTTA[2], PARTHO SARATHI GOOH PATTADER[3], DIPANKAR BANDYOPADHYAY[4], IIT Guwahati — We experimentally demonstrate three distinctive regimes of instabilities in a pressure-driven flow of a pair of viscosity stratified dielectric miscible fluids, inside a microchannel, upon application of electric field – a linear-onset regime, a time-periodic non-linear regime with the generation of vortices qualitatively similar to the von Kármán vortex street, and eventually a coherent regime which leads to the mixing of the two fluids. A linear stability analysis reveals the occurrence of five finite wavenumber modes of instabilities. The electro-hydrodynamic stresses originating upon application of electric field stimulate a pair of shorter-wavelength electric field modes E-I and E-II beyond a critical value of electric Rayleigh number. For higher viscosity difference between the fluids, the relative longer wavelength viscous mode (V-mode) appears. Beyond a critical Schmidt number, a diffusive mode (D-mode) appears, which is qualitatively similar to the interfacial instabilities of the immiscible fluids. The K-mode of instability appears due to contrast in ionic mobility values. The reported phenomenon can be harnessed for microscale mixing, pumping, heat and mass transfer, and reaction engineering.

[1]DST SERB, Grant no. EMR/2016/001824, Government of India
[2]Chemical Engineering, IIT Guwahati, India
[3]Chemical Engineering, IIT Guwahati, India
[4]Chemical Engineering, IIT Guwahati, India

Satarupa Dutta
IIT Guwahati

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