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Analysis and numerical modeling of electrohydrodynamic instability in a three-layer stratified flow VENKAT R.T. NARAYANAN, JIANBO LI, JEFFREY D. ZAHN, HAO LIN, Rutgers University — Organic-aqueous liquid (phenol) extraction is one of many standard techniques to efficiently purify DNA directly from cells. Effective dispersion of one fluid phase in the other increases the surface area over which biological component partitioning may occur, and hence enhances DNA extraction efficiency. Electrohydrodynamic (EHD) instability can be harnessed to achieve this goal, and has been experimentally demonstrated by one of the co-authors (JDZ). In this work, analysis and simulation are combined to investigate EHD instability in a three-layer, stratified, and immiscible microchannel flow. Such instability induces droplet formation, thereby increasing the interfacial area available for partitioning. A linear analysis is carried out with a Chebyshev pseudo-spectral method, whereas a fully nonlinear simulation is implemented using a finite volume, immersed boundary method. The results from both models compare favorably with each other. The linear analysis reveals basic instability characteristics such as kink and sausage modes, while the nonlinear simulation predicts surface deformation in the strongly nonlinear regime pertinent to droplet formation. The eventual objective is to utilize these numerical tools to determine relevant parameters for maximizing interfacial surface area for optimized DNA extraction.

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