QUANTIFICATION OF BY CONVECTIVE ELECTROKINETIC INSTABILITY MICROMIXING USING ION INDICATING DYES

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Electrokinetic instabilities (EKI) result from a coupling of electric fields and ionic conductivity gradients. The coupling of an electric field and a conductivity gradient results in an electric body force (per unit volume) of the form, $\rho_E \vec{E} = (\epsilon \vec{E} \cdot \nabla\sigma/\sigma)\vec{E}$ where ϵ, $\vec{E}$, and σ are the local values of permittivity, electric field, and ionic conductivity, respectively. This coupling results in an electric body force in the bulk liquid, outside the electric double layer, that can generate temporal, convective, and absolute flow instabilities. Electrokinetic flows with conductivity gradients become unstable when the electroviscous stretching and folding of conductivity interfaces grows faster than the dissipative effect of molecular diffusion [1]. We have presented both detailed models and experiments of electrokinetically unstable flows in microchannels [1, 2, 3, 4]. These studies collectively provide a fundamental understanding of electrokinetic instabilities, identify key controlling parameters, present predictive simulations, and determine the conditions for instability onset. We have recently shown that strongly unstable convective electrokinetic flows exhibit behavior consistent with nonlinear dynamic systems [5].

In this work, we experimentally quantify sample micromixing owing to convective electrokinetic instabilities using epifluorescence microscopy. We measure the degree of mixing by quantifying the fluorescence yield of an ion indicating dye. The quantum efficiency of ion indicating dyes increase by a factor of 100 or more when bound to specific ionic species. We seed the sample stream with ion indicating dye and the buffer streams with the target ion. As the sample and buffer streams mix, the ion indicating dyes and target ions bind and fluorescence yield increases. The measured fluorescence intensity in the microchannel is a direct measurement of mixing.

We will show that the degree of mixing increases with increasing field (for a fixed ionic conductivity ratio) and that nearly complete mixing can be obtained in less than 10 microchannel widths.

References

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