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Dielectrophoretic gating and phase separation of particles for micro- and nano-fluidic biodetection applications[1]

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Performance metrics for biological detection systems are significantly impacted by their ability to separate target analytes from background materials, a process that aids in the elimination of false positives. We report here several implementations of an electro-hydrodynamic technique for separating analytes in nanoliter sample volumes. This technique, AC dielectrophoresis (DEP) accompanied by field-induced phase transitions, includes electric field- and shear-induced phenomena to modify local concentrations of suspended particles. This non-optical separation technique relies upon intrinsic electric polarizability, and thus requires no time-consuming and costly labeling steps. We have demonstrated biological and non-biological particle separation, and both batch-mode and continuous flow configurations have been developed. The dielectrophoretic gating technique has been optimized to produce large electric field gradients($\nabla E^2 \sim 10^{20} V^2/m^3$) and we are currently applying this technique for particle chaperone preconcentration and nucleic acid purification. For the first application, we have achieved 100x preconcentration factors and high efficiency particle valving with no degradation in flowrate. This technique will prove useful for bead-based assay systems utilizing packed beds or high throughput flow cytometry. In the second application, we have preconcentrated dsDNA target molecules, and shown that preconcentration of false-positive inducing ssDNA reporter oligonucleotides is negligible. This method can be integrated on-chip, providing a significant advantage over conventional off-chip purification technologies such as centrifugation and precipitation. We will also present our results in traveling wave DEP, a technique which utilizes phase-quadrature signals to preconcentrate and transport particles without the use of hydrodynamic forces.

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