Microfluidic Processing of DNA Molecules Using Flow and Electric Fields

The efficient and innovative processing of bio-macromolecules relies increasingly on their transport through sub-millimeter geometries, or microfluidic devices. The desire to innovate is clear, as improvements in the ability to detect, concentrate, and separate biologically relevant molecules such as DNA and proteins will accelerate fundamental advances in biomedical technologies, drug discovery, biological testing, and more.

We have been investigating a method to control the transport of polyelectrolytes, and DNA in particular, within microfluidic channels. The method uses parallel and anti-parallel flow and electric fields to either migrate DNA toward the channel walls or to focus DNA along the centerline. The migration can be exploited to not only concentrate, but also to purify DNA within a microfluidic device of simple design. Experimental evidence of the migration and the associated ability to purify DNA are given. Additionally, an electro-hydrodynamic interaction is identified as the key physical mechanism that drives the migration, and predictions of theories and simulations incorporating these interactions are compared with experimental results. The phenomena discussed here represents a revolutionary insight into the electrokinetics of polyelectrolytes in general, and DNA specifically. Also, this innovative and unique approach to manipulating DNA, and other polyelectrolytes, holds much promise for many applications within biotechnology.

Dr. Jason E. Butler
Professor, Chemical Engineering,
University of Florida, Gainesville, FL

Jason E. Butler is a Professor Chemical Engineering at the University of Florida (Gainesville, FL). Dr. Butler completed his doctoral work at the University of Texas at Austin and post-doctoral work at Stanford University. Prior to joining the faculty at the University of Florida in 2001, Dr. Butler also worked at Aix-Marseille University in Marseille, France, where he still frequently visits. Dr. Butler’s research interests encompass dynamic phenomena within complex multiphase fluids using experimental, computational, and theoretical methods. His research in the field of complex fluids spans theoretical, computational, and experimental approaches to resolving questions that impact applications in fields such as microfluidics and slurry flows. Among other achievements, Dr. Butler has contributed to the theory and modeling of sedimentation and rheology of non-spherical particles, the Brownian dynamics of rigid polymers and Brownian rods, and the electrokinetics of polyelectrolytes.