Preface to Special Topic: Dielectrophoresis

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This Special Topic section is on dielectrophoresis, a growing area of widespread interest and relevance to the microfluidics and nanofluidics community. © 2010 American Institute of Physics. [doi:[10.1063/1.3457488](https://doi.org/10.1063/1.3457488)]

There was a time when the arrival of a telegram from the local post office would foreshadow a step-function change in one's equilibrium. An internet service provider can now deliver the same effect, as illustrated by an unexpected e-mail from Leslie Yeo inquiring if I would “be interested in guest editing a special issue of Biomicrofluidics on recent advances in dielectrophoresis (DEP).” Flattery directed towards vanity can produce interesting results—which I hope this special issue of Biomicrofluidics demonstrates. The rationale for this special issue is the belief of the journal's Editors (Dr. Chia Chang and Dr. Leslie Yeo) that dielectrophoresis is a growing area of widespread interest and relevance to the microfluidics and nanofluidics community. Papers, both fundamental and applied, were solicited from the leaders working across this broad interdisciplinary area of research. I was delighted by the positive responses of those whose invited contributions appear in this special issue—efforts certainly not motivated by vanity but through enthusiasm for the subject. Some of those invited to contribute were unable to do so because of other demands on their time. Ongoing advances being made in DEP, especially in its various applications, will surely merit another special issue in the future and hopefully include contributions from those unable to do so now.

Two of the papers in this special issue address fundamental aspects of dielectrophoresis (DEP), namely the influences on DEP from electrical double-layers and from particle-particle interactions. Consideration of electrical double layers associated with charged particle surfaces is particularly important for nanoparticles because their effective polarizabilities, associated with field-induced dynamics of the counterions and co-ions in the double layer, can dominate over the intrinsic polarizability of the particle itself. This can influence, for example, to what extent the observation of changes in the DEP crossover frequency (marking the transition between positive and negative DEP) can be relied upon in new immunoassays based on the DEP behavior of functionalized nanoparticles. By considering the electrodynamics of double layers, Basuray *et al.*¹ propose a theory to predict how the DEP crossover frequency will vary as a function of particle size and the ionic strength of the suspending electrolyte. In their paper, Sancho *et al.*² derive a theoretical model to describe how particle-particle interactions (e.g., “pearl-chaining”) influence the DEP crossover frequency value. This model also describes well the changes in electrorotation and a newly observed precession effect as particles approach each other under the influence of a rotating field.

DEP at the nanoscale is also addressed in contributions from the groups of Ralph Hölzel, Junya Suehiro, and Karan Kaler. Thus, Henning *et al.*³ describe a new method, based on the measurement of capacitance changes between planar microelectrodes, for the automatic acquisition of the DEP properties of nanoparticles without the need for labeling protocols or visual observations. Suehiro⁴ describes how DEP can be employed as a bottom-up approach for fabricating nanomaterial-based devices such as a carbon nanotube gas sensor and a ZnO nanowire photosensor. Kaler *et al.*⁵ describe how the DEP manipulation of miniscule amounts of polar aqueous samples, a method known as liquid-DEP, can be used for on-chip bioassays, such as nucleic acid analysis, and through parallel sample processing offer the potential for conducting automated multiplexed assays. The use of DEP to selectively trap and separate cells has been

investigated over many years, and contributions from the groups of Hywel Morgan, Ana Valero, Masau Washizu, and Gerard Markx describe the latest advances and applications. Thomas *et al.*⁶ describe a new automated DEP cell trap design for the isolation, concentration, separation, and recovery of human osteoblast-like cells from a heterogeneous population. Recovery of small populations of human osteoblast-like cells with a purity of 100% is demonstrated. A cell-sorting device, based on the opposition of DEP forces that discriminates between cell types according to such properties as their membrane permittivity and cytoplasm conductivity, is described by Valero *et al.*⁷ The versatility of the device is demonstrated by synchronizing a yeast cell culture at a particular phase of the cell cycle. Gel *et al.*⁸ describe a DEP-assisted cell trapping method for fusing pairs of cells in an array of micro-orifices. This method produces not only a high yield of viable cell fusants, but also allows for subsequent study of postfusion cell development. Zhu *et al.*⁹ describe a DEP-based microfluidic separation system in which dead and active cells can be collected from a given cell suspension, whilst at the same time eluting dormant cells. In the second paper from Gerard Markx's group, Zhu *et al.*¹⁰ demonstrate that the rate-limiting resuscitation of a colony of dormant bacteria is determined by the diffusion of a resuscitation-promoting factor into the colony interior. This study involved the artificial engineering of different sizes and shapes of bacterial aggregates using DEP forces. Finally, in my own contribution,¹¹ I have attempted to summarize the growing output of DEP publications in terms of their contributions to the theory, technology, and applications of DEP.

It has been a pleasure to work with Leslie Yeo and Chia Chang. I have appreciated their enthusiastic support and thank them for their initial kind compliment. I also thank Linda Boniello at the publishing offices of the American Institute of Physics for all her expert and timely assistance during the various stages of this exercise. But special thanks must go to all the contributors, because without their collective efforts this special issue would not exist.

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⁴ J. Suehiro, *Biomicrofluidics* 4, 022804 (2010).

⁵ K. V. I. S. Kaler, R. Prakash, and D. Chugh, *Biomicrofluidics* 4, 022805 (2010).

⁶ R. S. W. Thomas, P. D. Mitchell, R. O. C. Oreffo, and H. Morgan, *Biomicrofluidics* 4, 022806 (2010).

⁷ A. Valero, T. Braschler, N. Demierre, and P. Renaud, *Biomicrofluidics* 4, 022807 (2010).

⁸ M. Gel, Y. Kimura, O. Kurosawa, H. Oana, H. Kotera, and M. Washizu, *Biomicrofluidics* 4, 022808 (2010).

⁹ K. Zhu, A. S. Kaprelyants, E. G. Salina, and G. H. Markx, *Biomicrofluidics* 4, 022809 (2010).

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¹¹ R. Pethig, *Biomicrofluidics* 4, 022811 (2010).