In-Plane Electrophoresis in Nonpolar Liquids

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In-plane (lateral) electrophoresis is electrophoresis in which charged particles are transported parallel to the plane of the insulating substrates between which the liquid is placed. This is in contrast to out-of-plane (transversal) electrophoresis in which particles are moving perpendicular to this plane. Here, in-plane electrophoresis is studied in a nonpolar liquid because this configuration is common in recently developed in-plane electronic paper [1,2]. The current understanding of the complex electrodynamics and particle transport in electrophoretic displays is largely based on electrical current measurements and optical experiments with out-of-plane devices [3,4,5]. The similar understanding of in-plane electrophoretic displays is however limited to just a few studies [6,7].

A theoretical study of in-plane electrophoresis is carried out using the Poisson-Nernst-Planck (PNP) equations which describe drift and diffusion of charged species without chemical reactions or convection. Because solving the full 2-dimensional PNP equations is time consuming and because details of the lateral motion are often only of secondary importance, we developed a 1-dimensional approximation. This 1-dimensional approximation is obtained by using Green's functions and the superposition theorem to describe the electric potential between the electrodes due to the applied voltage and space charge. It is verified that the 1-dimensional approximation is in good agreement with the solution of the full 2D PNP equations in the case of a sufficiently thin in-plane device. We used the 1D approximation to analyze different regimes of in-plane transient electrophoresis, in which a step voltage is applied at a certain time. A comparison is made with out-of-plane (transversal) transient electrophoresis. Finally, the results from the simulations are compared to experiments of in-plane electrophoresis in which the electric current is measured and the in-plane component of the electric field is measured by optical tracking of tracer particles.

[1] K.-M. H. Lenssen *et al*. SID Symposium, **39**, 685 (2008).
[2] K.-M. H. Lenssen *et al*. Journal of the SID, **17**, 383 (2009).
[3] A. R. M. Verschueren, P. H. L. Notten, L. J. M. Schlangen, F. Strubbe, F. Beunis and K. Neyts, J. Phys. Chem. B. **112**, 41 (2008).
[4] F. Strubbe, F. Beunis, M. Marescaux, B. Verboven and K. Neyts, Appl. Phys. Lett. 93, 254106 (2008).
[5] F. Beunis, F. Strubbe, M. Marescaux, J. Beeckman, A. R. M. Verschueren and K. Neyts, Phys. Rev. E **78**, 011502 (2008).
[6] J. Kim, S. Garoff, J. L. Anderson and L. J. M. Schlangen, Langmuir **21**, 10941 (2005).
[7] J. Kim, J. L. Anderson, S. Garoff and L. J. M. Schlangen, Langmuir, **22**, 7942 (2006).