Electronic Supplementary Material (ESI) for Soft Matter.
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Characterization of band broadening in DNA electrohydrodynamic migration for enhanced size separation

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Supplementary Material

Width of the DNA band with an electric field linearly decreasing over time

Let us first evaluate the passage time t_p in front of the detector. For this, we invert the migration velocity knowing the distance to the detector L_p:

$$L_p = \int_0^{t_p} U_{VE}(u).du \tag{S1}$$

The electrohydrodynamic velocity is given by (Eq. (9)) and we define the slope α of the decrease of the electric field as :

$$\begin{gathered} U_e(t) = U_0 - \alpha.t \\ U_{VE}(t) = \frac{6U_h}{H}\langle\varepsilon\rangle(t) - U_e(t) = \frac{6U_h}{H}\sqrt{\frac{2k_BT}{\pi}\frac{H^2}{a\mu\tau U_h U_e(t)}} - U_e(t) \end{gathered} \tag{S2}$$

Integration of Eq. (S2) leads to the following polynomial equation, that can be solved numerically to determine t_p:

$$\begin{gathered} L_p = \frac{{U_0}^2}{2\alpha}\left(1 - \alpha.t_p/U_0\right)^2 - \frac{2K\sqrt{U_0}}{\alpha}\sqrt{1 - \alpha.t_p/U_0} - \frac{{U_0}^2}{2\alpha} + \frac{2K\sqrt{U_0}}{\alpha} \\ K = \frac{6U_h}{H}\sqrt{\frac{2k_BT}{\pi}\frac{H^2}{a\mu\tau U_h}} = \sqrt{\frac{72}{\pi}}\sqrt{\frac{k_BTU_h}{a\mu\tau}} \end{gathered} \tag{S3}$$

The width of the band is finally determined using Eq. (11) according to:

$$w_p = w_0 + \sqrt{2 \times 44 \times \frac{H^2}{\tau^2} \times \int_0^{t_p} \frac{dt}{(U_0 - \alpha.t)^2}} \tag{S4}$$

These equations are solved numerically with the following set of parameters: $k_B = 6\ 10^{-23}$ J/K; T = 300 K ; a = (N_bp/300)*lk = 200 nm ; $\tau = 0.5\ 10^{-3}$ s ; $\mu = 30\ 10^{-3}$ Pa.s ; $H = 2\ 10^{-6}$ m ; Lp = 1.3 mm ; $U_h = 1.7\ 10^{-3}$ m/s ; w_0=0.05 mm. The value of U_0 is computed from the conditions of arrest at t=0 (Eq. S2), yielding U_0=800 µm/s.

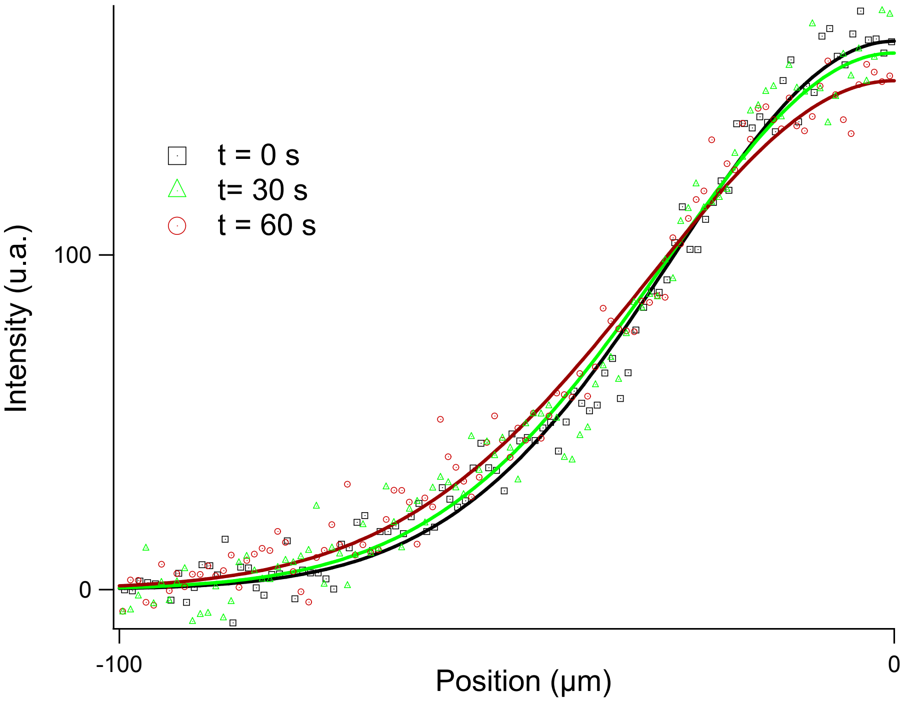

Figure S1: The plot presents the half-spatial intensity distribution of a 600 bp DNA band. Spreads is due to Brownian dispersion. Each dataset is fitted with a Gaussian function (solid lines).

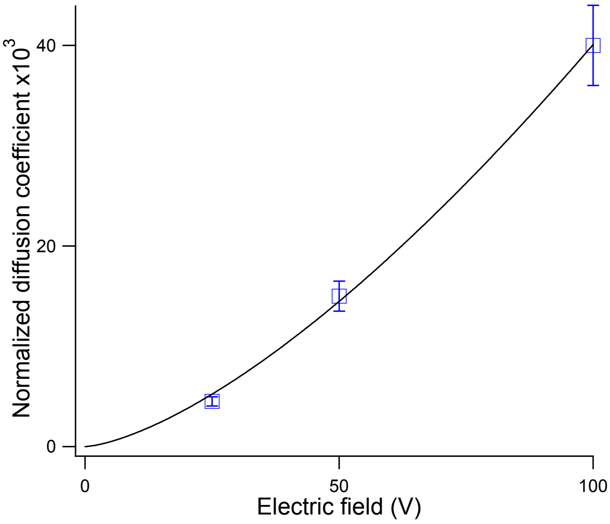

Figure S2: The plot presents the steady value of the normalized electrophoretic diffusion coefficient, inferred from Fig. 3, as a function of the electric field. The solid line is a fit of the data associated to a power-law scaling response of 1.47, given that the normalized diffusion coefficient is set to 1 at zero electric field.

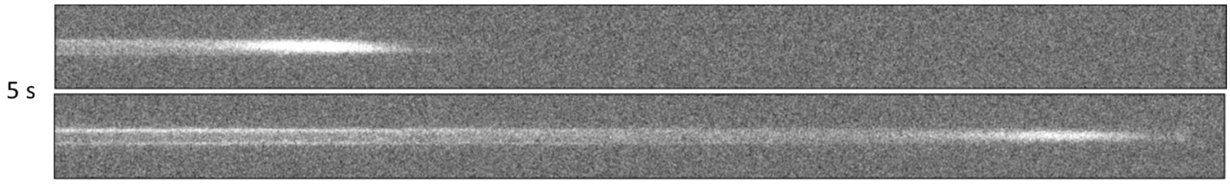

Figure S3: The two fluorescence micrographs present the migration of a DNA band with a constant electric field of 20 V and a pressure of 2 bar. The time interval between the two images is 5 s. The band appears to “leak” near the side walls. This result is due to the boundary conditions for a rectangular channel of 10 µm in width and 2 µm in height. The flow velocity field is slowed down near the walls over a distance of ~1 µm. The electric field is thus comparatively higher in this region, and the band migration is further slowed down.