Tuning the electrophoretic separations on a surface accessible and flexible fibre-based microfluidic devices

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S1. Optimization of sample molar ratio

In a typical capillary zone electrophoresis column when an electric field is applied, charged solutes move as a result of the hydrodynamic drag of electrolyte and electromigration of the charged solute itself. The apparent velocity of both the electrolyte molecules and the charge solute is directly related to the magnitude of the applied electrical field (Equation 1).

$$\nu = E\mu \qquad\qquad 1$$

Where, ν is the apparent velocity of moving solute (cms^{-1}), E is applied electric field (Vcm^{-1}) and μ is the mobility of solute (cm^{2}V^{-1}s^{-1}). When an electric field is applied to more than one solute in a sample mixture, different solutes will move in an order of higher charge to size ratio (Equation 2).

$$\mu = \frac{q}{6\pi\eta r}$$

$$2$$

Where q is the charge on the particle, r is the size of the particle and η is the viscosity of solution.

According to Faraday's law, the total charge, q, on a solute is proportional to the absolute amount of solute in a mixture (Equation 3).

$$q = nFN_A \qquad\qquad 3$$

where F is the Faraday's constant, n is the number of electrons per mole of solute and N_A is the number of moles of solute.

For effective electrophoretic separation, the concentration of two solutes in a sample mixture should be in a ratio of differing charge to size ratio. Therefore, different combinations of molar concentration (1:10, 1:20, 1:40, 1:60, 1:80) of FL: Rh-B were studied and optimized for effective separation.

The binary images of the separation zone between FL (left) and Rh-B (right) at different electric fields and molar ratio of FL and Rh-B are shown in Figure S1.1. Separation resolution (SR) was calculated for each experimental condition following the same procedure presented in main manuscript.

When the solute molar ratio was lower such as 1:10, separation between FL and Rh-B was observed at a small applied electric field (100 Vcm^{-1}). However, as the solute molar ratio was increased, higher electric fields were required to separate the two solutes. The observed behaviour was due to the high diffusion and increase in solute fiber interaction at higher concentrations. Also, due to reduction in EOF at lower electric fields, longer time was required to fully resolved the two solutes at lower concentrations. Therefore, molar concentration of FL and Rh-B was standardized as 1:60 for all experiments.
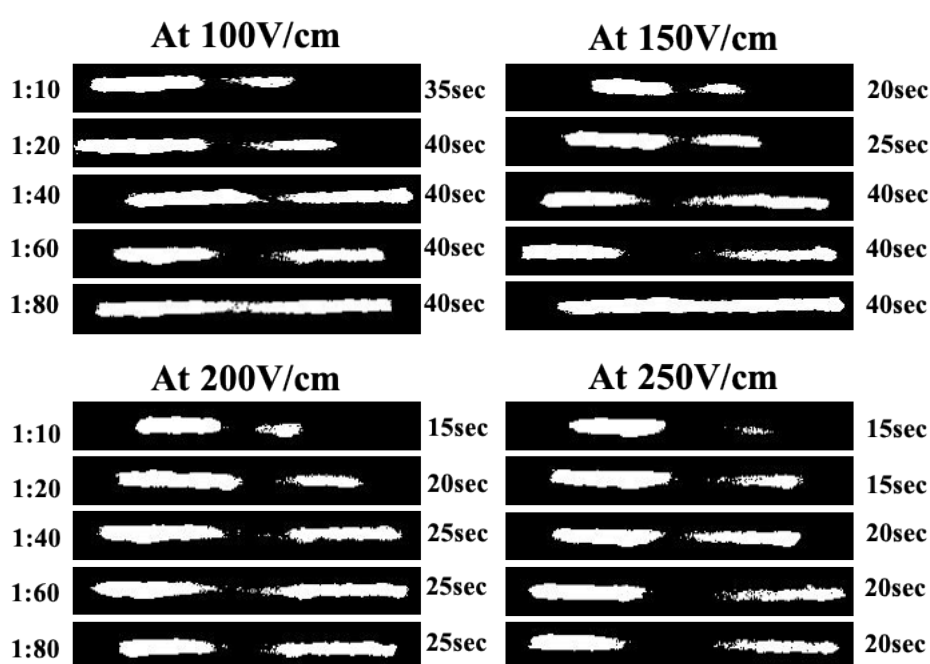

Figure S1. Binary images of the separation zone between FL (left) and Rh-B (right) at different voltages and molar ratios.

Table S1. Full BBD design of experiment

StdOrder	RunOrder	PtType	Blocks	Experimental Factors		
				Electric Field, Vcm^{-1}	Sample Volume, µL	Sample Concentration, mM
7	1	2	1	100	0.5	6
12	2	2	1	175	0.75	6
15	3	0	1	175	0.5	4.5
6	4	2	1	250	0.5	3

8	5	2	1	250	0.5	6
9	6	2	1	175	0.25	3
13	7	0	1	175	0.5	4.5
14	8	0	1	175	0.5	4.5
4	9	2	1	250	0.75	4.5
11	10	2	1	175	0.25	6
3	11	2	1	100	0.75	4.5
2	12	2	1	250	0.25	4.5
10	13	2	1	175	0.75	3
5	14	2	1	100	0.5	3
1	15	2	1	100	0.25	4.5
32	16	2	3	250	0.25	4.5
45	17	0	3	175	0.5	4.5
41	18	2	3	175	0.25	6
33	19	2	3	100	0.75	4.5
39	20	2	3	175	0.25	3
43	21	0	3	175	0.5	4.5
38	22	2	3	250	0.5	6
34	23	2	3	250	0.75	4.5
44	24	0	3	175	0.5	4.5
36	25	2	3	250	0.5	3
35	26	2	3	100	0.5	3
31	27	2	3	100	0.25	4.5
42	28	2	3	175	0.75	6
40	29	2	3	175	0.75	3
37	30	2	3	100	0.5	6
28	31	0	2	175	0.5	4.5
25	32	2	2	175	0.75	3
16	33	2	2	100	0.25	4.5
17	34	2	2	250	0.25	4.5
29	35	0	2	175	0.5	4.5
20	36	2	2	100	0.5	3
24	37	2	2	175	0.25	3
30	38	0	2	175	0.5	4.5
27	39	2	2	175	0.75	6

23	40	2	2	250	0.5	6
19	41	2	2	250	0.75	4.5
21	42	2	2	250	0.5	3
22	43	2	2	100	0.5	6
26	44	2	2	175	0.25	6
18	45	2	2	100	0.75	4.5

Table S2. Comparison of EOF and electrophoretic mobilities (μ) of FL and Rh-B on polyester braided structure and micro-channel

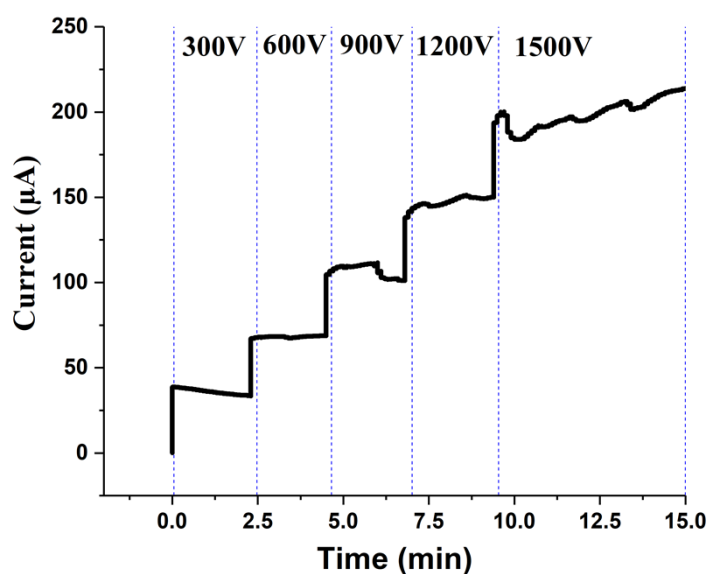| Channel type	pH	Electric field (Vcm^{-1})	EOF $(10^{-4}\,cm^2\,V^{-1}\,sec^{-1})$	μ $(10^{-4}\,cm^2\,V^{-1}\,sec^{-1})$	
				FL	Rh-B
6-yarn polyester braid	8.8	250	4.60	2.08	4.26
Microchip[1]	9	250	5.37	3.27	5.25

Figure S2. Changed in ohmic current values as a function of time at a constant driving voltage of 300, 600, 900, 1200 and 1500 (V) for 2.5 mins at each voltage, using 6 cm long polyester braided structure and 2.5 mM TRIS/CHES as BGE at pH 8.8.

References

(1)   Shakalisava, Y.; Poitevin, M.; Viovy, J. L.; Descroix, S. Versatile Method for Electroosmotic Flow Measurements in Microchip Electrophoresis. *J. Chromatogr. A* **2009**, *1216* (6), 1030–1033.