

Supplementary Information

Experimental Section

The microfluidic device is hybrid PDMS/glass. Templates were made from PerMX photoresist (DuPont, NC, USA) according to manufacturer's instructions. All microchannels were 30 μm deep. The V-shaped sample channel (500 μm wide and 13 mm long) was separated from the separation channel by a 100 μm gap. Separation channel was 50 μm wide and 47.5 mm long; effective length was 45.0 mm.

A 10:1 (w/w) mixture of Sylgard 184 PDMS elastomer base and curing agent (Dow Corning Corporation, Midland, MI, USA) was degassed, cast on the template, and cured for 1 h at 70°C. PDMS and soda glass slide were plasma treated with handheld corona discharge device (model BD-20, 230 V power supply, Electro Technic Products) for 15 s and placed in conformal contact for 12 h at 65°C for irreversible bonding.

To form the nanochannels, a potential difference of 2200 V (electric field strength 22 V/ μm) was applied across the PDMS gap with both the sample V and the microchannels filled with electrolyte.

An in-house, 4-channel power supply (0 – 10 kV) was used to apply electric field to the microfluidic device through 5 platinum electrodes. The 2 electrodes connected to sample reservoirs share the same applied voltage. A LabView 8.6 program (National Instruments, Austin, TX, USA) was used to control the power supply. Solutions of 1 mM disodium hydrogen phosphate ($\text{Na}_2\text{HPO}_4 \cdot 2\text{H}_2\text{O}$) from Sigma-Aldrich (Steinheim, Germany) was used as the breakdown electrolyte. All solutions were prepared in Milli-Q water obtained from a Millipore (North Ryde, Australia) purification system.

Permeability was tested using different size and charge analytes. CNF from Molecular Probes (Oregon, USA) was prepared in 10 mM phosphate solution (pH 11.7) to obtain 200 $\mu\text{g mL}^{-1}$ solution. BSA was labelled with fluorescamine by mixing 200 μL of 250 $\mu\text{g mL}^{-1}$ in 10 mM phosphate and 0.9% (w/v) NaCl, with 20 μL of 10 mM fluorescamine in acetone. BSA and fluorescamine were obtained from Sigma-Aldrich (Steinheim, Germany) and NaCl from Merck (Darmstadt, Germany). R-phycoerythrin was obtained from Sigma-Aldrich (MO, USA). Background electrolyte was 10 mM borate buffer (pH 9.3) with 0.1% (w/v) HPMC from Sigma-Aldrich (Steinheim, Germany) to suppress EOF. Simultaneous transport of inorganic ions was done using 0.1 g mL^{-1} solutions of iron (III) nitrate ($\text{Fe}(\text{NO}_3)_3 \cdot 9\text{H}_2\text{O}$) from ChemSupply (Beverly, S.A., 5009) and potassium thiocyanate (KSCN) from Ajax chemicals (Sydney, Australia) in 100 mM nitric acid (HNO_3) from Merck (VIC, Australia). Permeability studies were recorded with a high-definition colour charge-coupled device camera head (Digital Sight DS-Fi1c, Nikon, Japan) mounted on an inverted fluorescence microscope (Nikon, Eclipse Ti-U, Japan) and operated with NIS-Elements BR 3.10 software (Melville, NY, USA). Multiband pass excitation (λ_{ex} at 390, 482, 563, and 640 nm) and emission (λ_{em} at 446, 523, 600, and 677 nm) filters (Semrock, Rochester, NY, USA) were used for all experiments.

For determination of quinine, whole blood samples from a healthy volunteer were treated with disodium EDTA to prevent coagulation and divided into small volumes (200 μL) then stored in the freezer. Quinine sulphate monohydrate from Aldrich (Milwaukee, USA) was used to prepare 100 mg mL^{-1} stock solution in 3 mM sulphuric acid. This solution was used to spike blood samples to obtain 1 mg mL^{-1} . Different concentrations (0.5, 1.0, 2.5, 10.0, and 25.0 $\mu\text{g mL}^{-1}$) were obtained by serial dilution with whole blood. The ITP system was a leading electrolyte of 10 mM sodium acetate (BDH, VIC, Australia), 20 mM acetic acid, 1 mM NaH_2PO_4 , (pH 4.3) in presence of 0.1% (w/v) HPMC and a terminating electrolyte of 10 mM β -alanine (Sigma-Aldrich, Steinheim, Germany) and 10 mM acetic acid (pH 4.2). Quantitative measurements were done using a photomultiplier tube (Hamamatsu Photonics KK, Hamamatsu, Japan) connected to the microscope. Data acquisition was made using an Agilent interface (35900E) connected to a laptop and operated by Agilent ChemStation for LC software (Agilent Technologies, Waldbronn, Germany).