Deformability-Selective Particle Entrainment and Separation in a Rectangular Microchannel Using Medium Viscoelasticity

Electronic Supplementary Information

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List of Supplementary Information

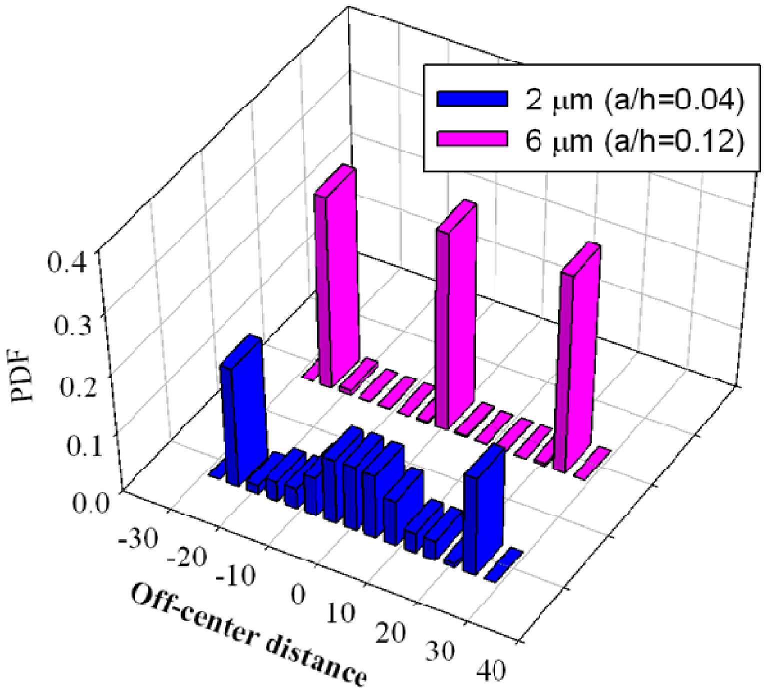
Supplementary Text S1: Deformability measurements

The deformation index (DI) was measured to characterize the deformability of red blood cells in a micro contraction/expansion channel, as described in previous work by the Stone group[1] (Supplementary Fig S2). The RBCs were treated with 0.01 wt% glutaraldehyde PBS solution to rigidify them. The deformation indices were analyzed from 20 cells passing through the boxes (yellow dotted lines) at each location presented in the figure (Supplementary Fig S2). The microchannel dimensions were the same as those presented in the figure (Supplementary Fig S2), and the channel height was 18 μm. Images were captured using a high-speed CCD (Photron, MC2) mounted on an inverted microscope (Olympus, IX71) at 8000 fps with an exposure time of 1/10000 s. The captured images were analyzed with ImageJ (NIH). The deformation index is defined as DI = (X-Y)/(X+Y), where X and Y are the maximum and minimum Feret diameters, respectively, of the RBCs.

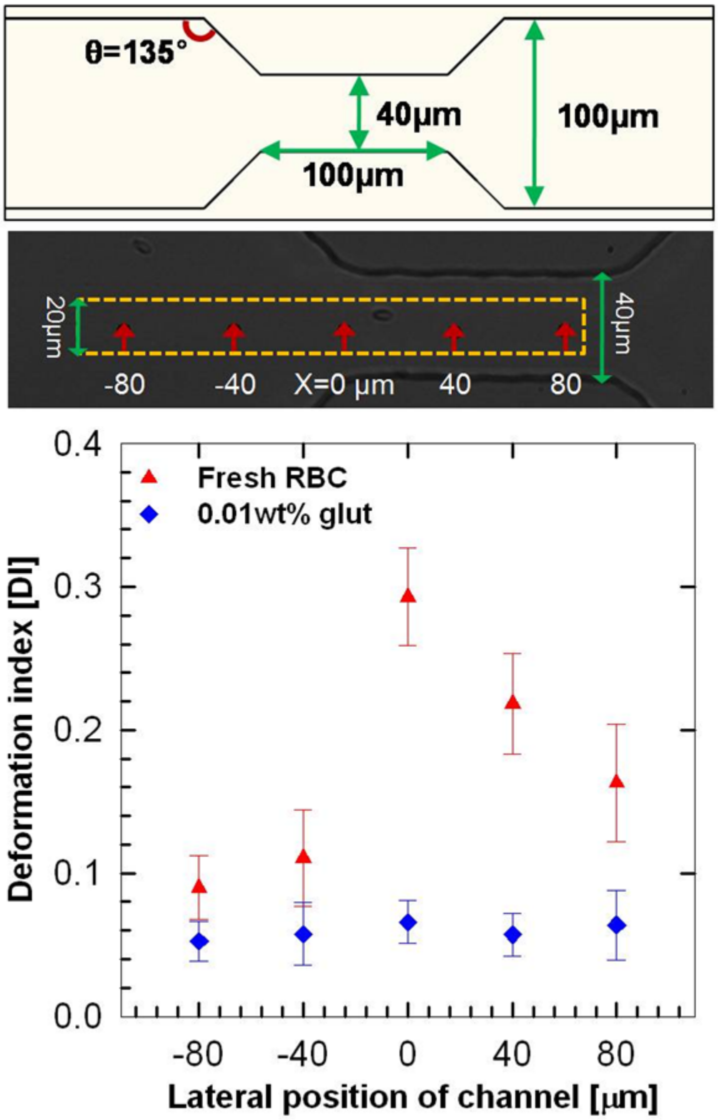
References in Supplementary Information

1. A. M. Forsyth, J. Wan, W. D. Ristenpart and H. A. Stone, *Microvas. Res.*, 2010, **80**, 37-43.

Supplementary Figures



Supplementary Fig. S1. The change in particle focusing according to the aspect ratio of particle size to channel height (*a/h*) under viscoelastic flows with negligible inertia (*Wi* > 0, *Re* ~ 0; cf. Supplementary Table S1) (PVP 6.8 wt% solution). The probability distribution functions (PDFs) were obtained for 2 μm and 6 μm particles 4 cm downstream from the inlets in a square channel (width×height = 50 μm× 50 μm) (an upright microscope (BX60M, Olympus) was used for this study). The flow rate was 80 μl/hr (*Wi*=0.1, *Re*=3.30×10^{-3}). Fig. S1 shows that the particle focusing depends greatly upon the aspect ratio (*a/h*): larger particles migrate more rapidly toward the equilibrium positions (centerline and corners) than smaller particles.



Supplementary Fig. S2. Deformability measurements: The deformation index (DI) was measured in a micro contraction/expansion channel similar to that used in previous work [1]. RBCs were rigidified by treatment with 0.01 wt% glutaraldehyde PBS solution. The deformation indices were analyzed from 20 cells passing through the box (yellow dotted lines) at each location presented in the top figure. (Top) Microchannel dimensions: channel height 18 μm. (Bottom) Deformation index: the captured images of deformed RBCs were analyzed with ImageJ (NIH). The deformation index is defined as DI = (X-Y)/(X+Y), where X and Y are the maximum and minimum Feret diameters, respectively, of the RBCs. The above data show the clear difference in deformability between fresh (normal) and glutaraldehyde-treated RBCs.

Supplementary Table

Supplementary Table S1. Non-dimensionalized numbers corresponding to flow conditions of Fig. 3. For a rectangular microchannel with the dimensions of height (h) × width (w), the characteristic shear rate ($\dot{\gamma}_c$) and length are $2Q/hw^2$ and $2hw/(h+w)$, respectively, at a flow rate of Q. The Reynolds number (*Re*) and Weissenberg number (*Wi*) are defined as $2\rho Q/\mu(h+w)$ and $2\lambda Q/hw^2$, respectively, where λ is the relaxation time and ρ is the density of the polymer solution.

Flow rate (ml/h)	6.8 wt% PVP solution	
	Wi	*Re*
0.01	0.01	4.13×10^{-4}
0.02	0.02	8.26×10^{-4}
0.04	0.05	1.65×10^{-3}
0.08	0.10	3.30×10^{-3}
0.16	0.20	6.61×10^{-3}
0.24	0.30	9.91×10^{-3}
0.48	0.59	1.98×10^{-2}

Supplementary Movie Legends

Supplementary Movie S1: Movie of bright-field images of the separation device at work (Fig. 3 in main text) for the PS bead/fresh RBC mixture at a flow rate of 0.16 mL/h (the images were acquired at 15 fps).

Supplementary Movie S2: Movie of bright-field images of the separation device at work (Fig. 3 in main text) for the rigidified (fixed) RBC/fresh RBC mixture at a flow rate of 0.16 mL/h (the images were acquired at 15 fps).

Supplementary Movie S3: Movie of fluorescent images of the separation device at work (Fig. 3 in main text) for the rigidified (fixed) RBC/fresh RBC mixture at a flow rate of 0.16 mL/h (the images were acquired at 13 fps).