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Electronic Supplementary Information

Two step label free particle separation in a microfluidic system using elasto-inertial focusing and magnetophoresis

Min Jung Kim, [a,1] Doo Jin Lee, [a,1] Jae Ryoun Youn, *[a] and Young Seok Song *[b]

[a] *Research Institute of Advanced Materials (RIAM), Department of Materials Science and Engineering, Seoul National University, Seoul 08826, Republic of Korea*

[b] *Department of Fiber System Engineering, Dankook University, Gyeonggi Do 16890, Republic of Korea*

*Corresponding author: Jae Ryoun Youn and Young Seok Song

Tel.: +82-2-880-8326; Fax: +82-2-885-9671; E-mail: jaeryoun@snu.ac.kr

Tel.: +82-31-8005-3567; Fax: +82-31-8005-2209; E-mail: ysong@dankook.ac.kr

[1]These authors contributed equally to this work.

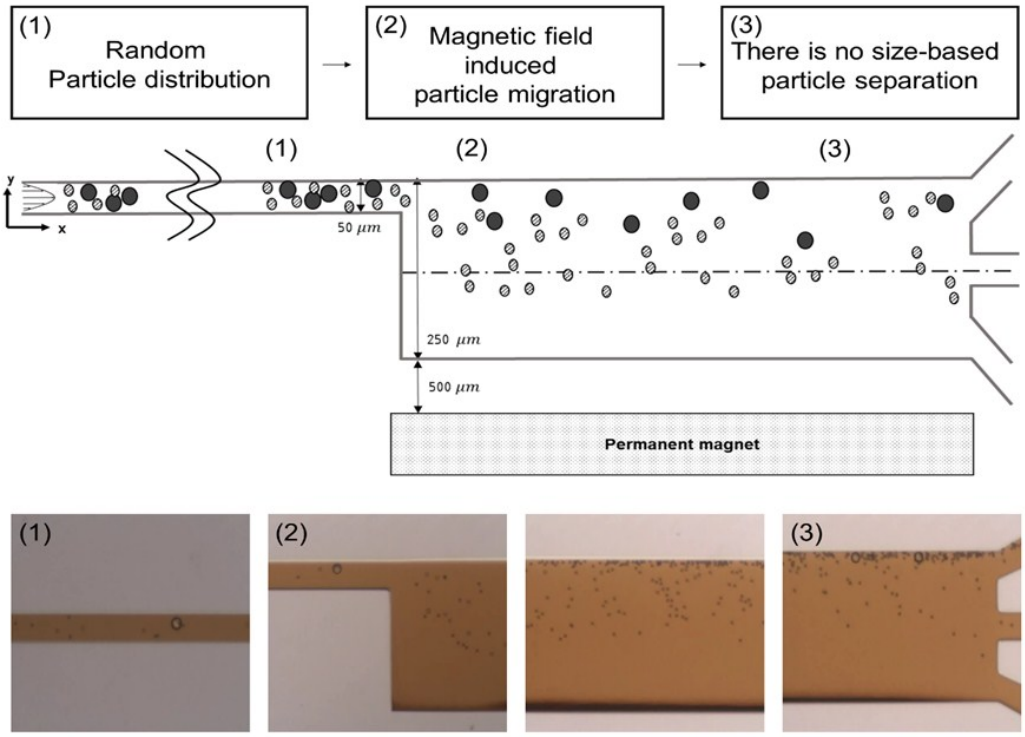

Fig. S1 Channel design and operating principle of the system. Different size particles with a Newtonian medium are randomly injected into an inlet of a microchannel: (1) Random particle distribution (2) Particles are randomly distributed after they undergo diverging flow. (3) Particles are not separated successfully without elasto-inertial focusing at the first stage.

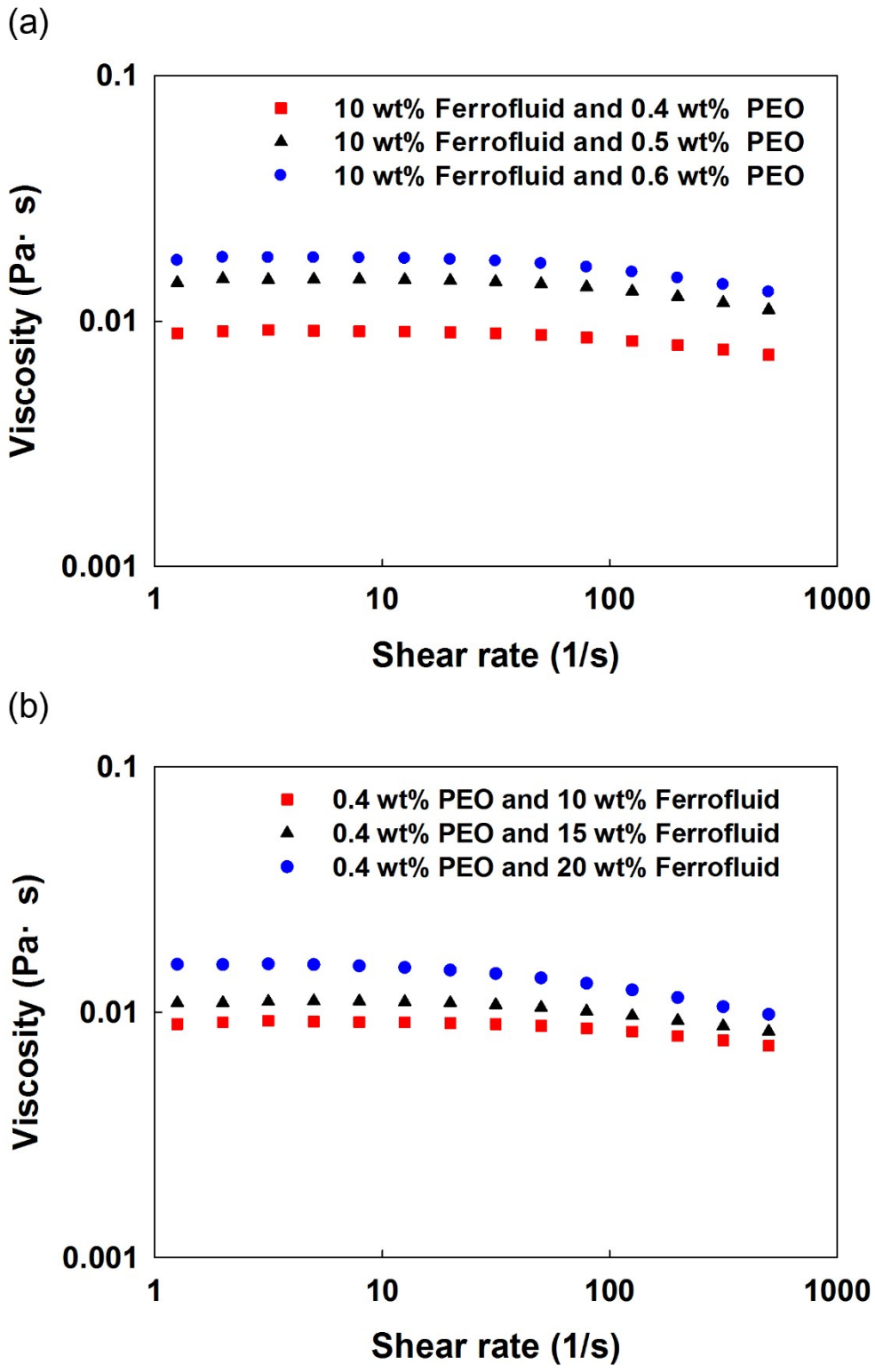

Fig. S2 Rheological properties of PEO/ferrofluid solutions. Viscosities at different concentrations of (a) PEO and (b) ferrofluid.

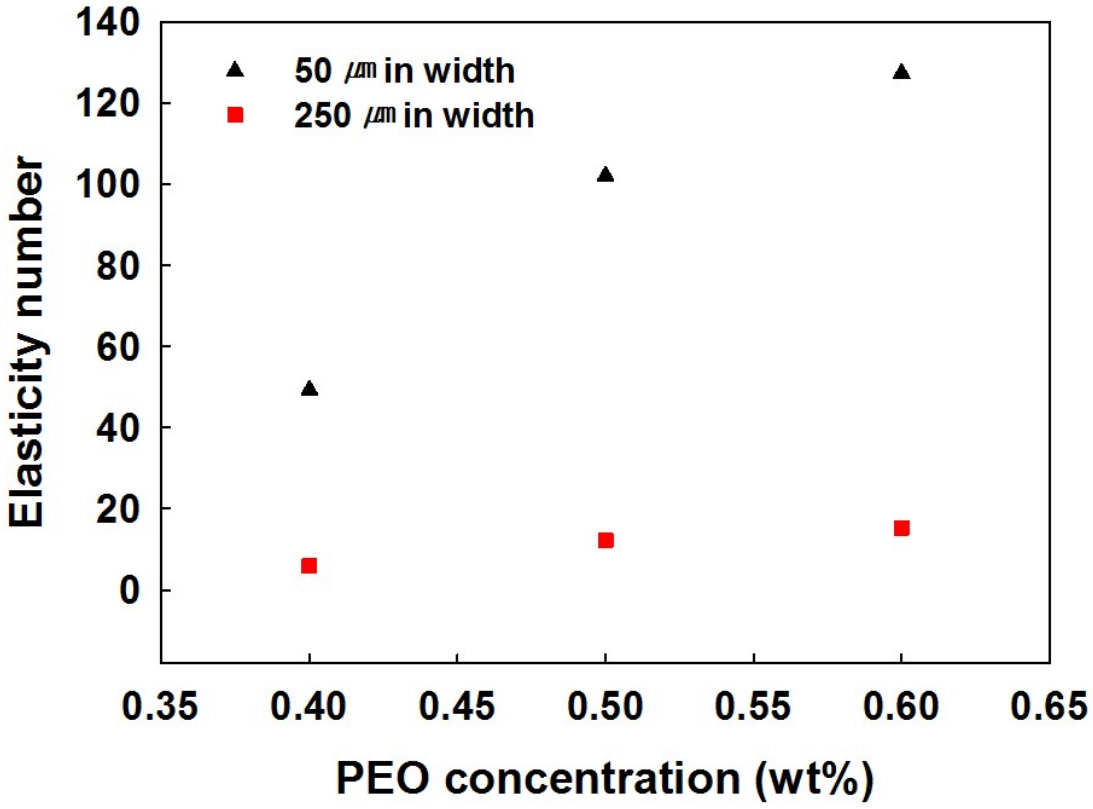

Fig. S3 Elasticity number (*El*) of PEO solutions with different concentrations and different channel dimensions. The elastic force at the first stage of the microchannel is larger than that at the second stage of the microchannel.

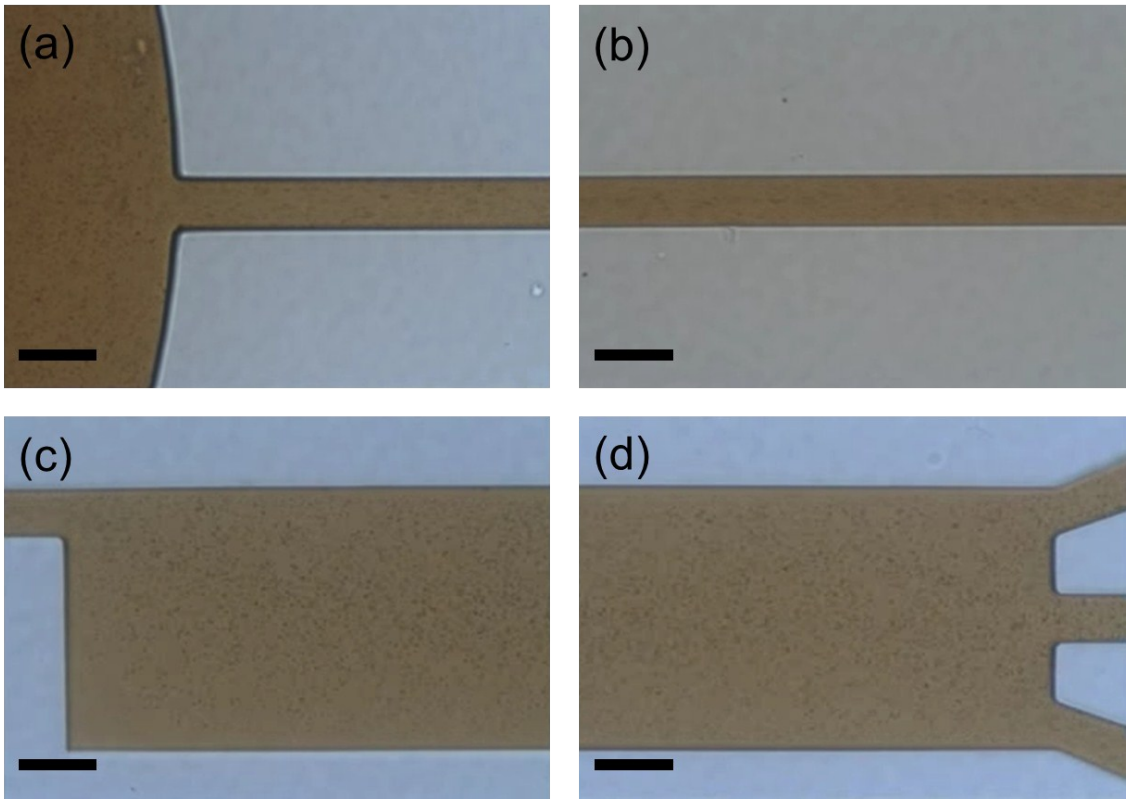

Fig. S4 1 μm PS particles suspended in a liquid sample with the concentration of 0.4 wt% PEO and 10 wt% ferrofluid at (a) an inlet, (b) straight channel with a blockage ratio $(D_p/D_h) = 0.02$, (c) diverging section, and (d) outlet section to downstream**.** A scale bar is 50 μm.

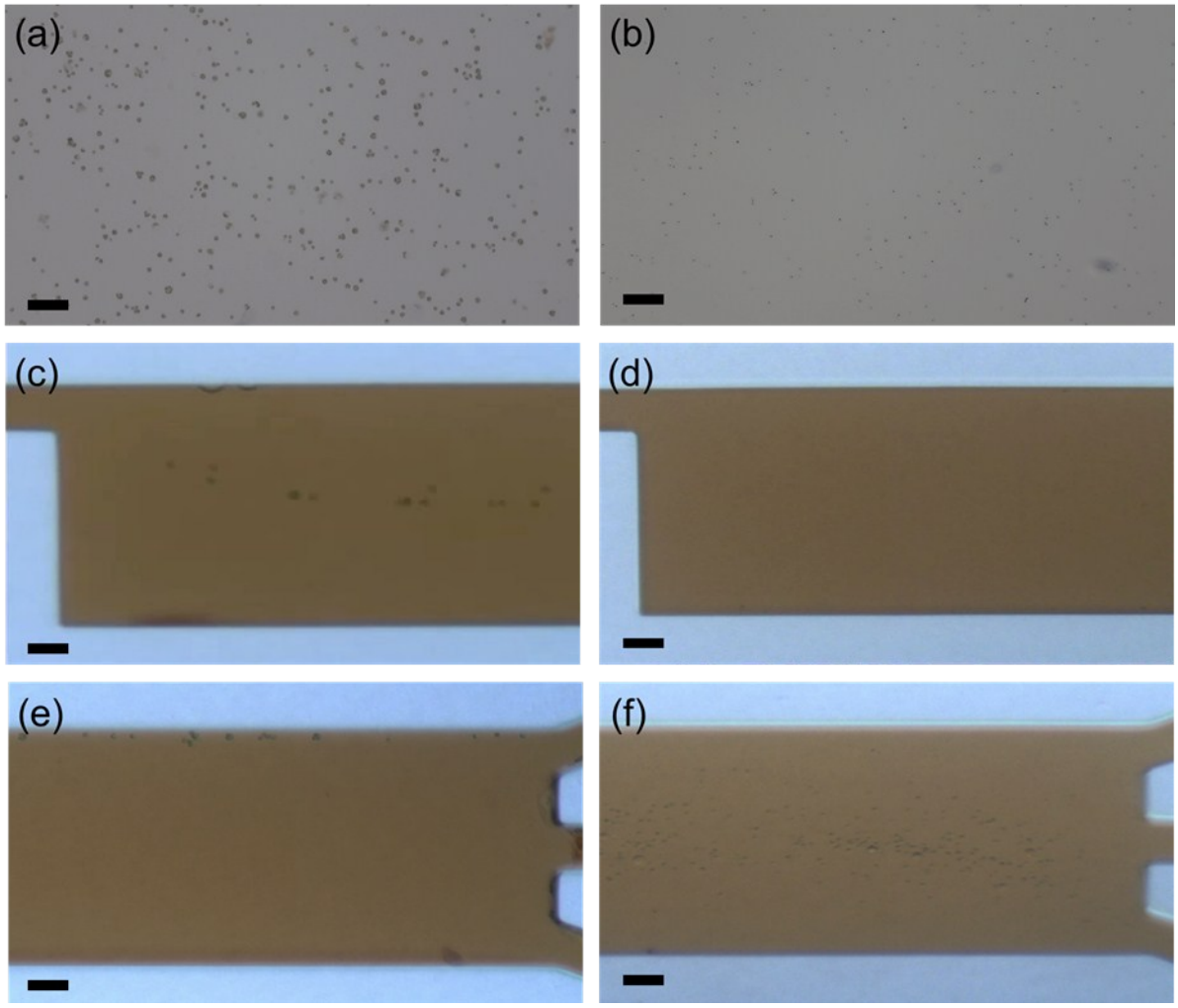

Fig. S5 A comparison of the sizes of (a) *Chlorella vulgaris* and (b) *Synechococcus sp.* cells. (c) *Chlorella vulgaris* cells focusing, and (d) *Synechococcus sp.* cells random distribution at the diverging region of the channel. (e) *Chlorella vulgaris* cells migration toward an upper channel wall and their collection in an outlet 1, and (f) Sy*nechococcus sp.* cells random distribution and their collection in outlet 2 and 3. A scale bar is 50 μm.

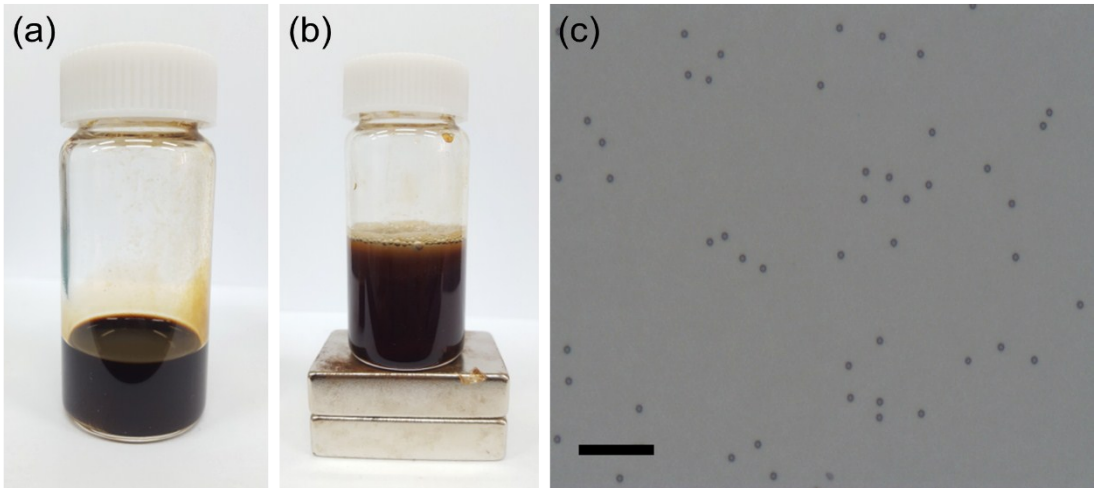

Fig. S6 Liquid samples collected from an outlet after experiments: (a) before sedimentation, and (b) after sedimentation of the component of ferrofluid owing to a magnet. A small amount of glycerol is added to the liquid sample to adjust the density of the liquid denser than PS particles. (c) PS particles obtained from the top surface of the liquid sample (b). A scale bar is 50 μm.

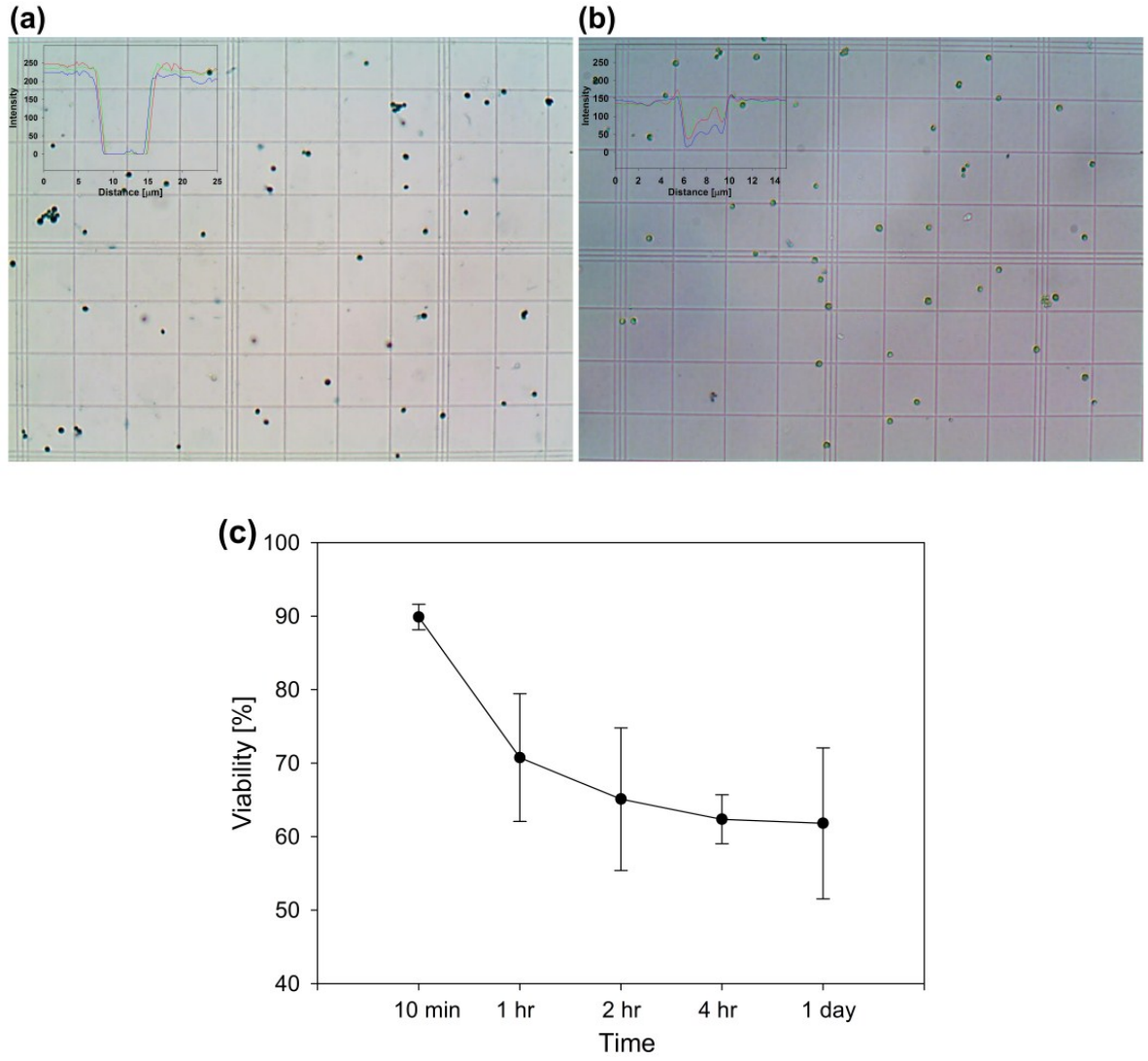

Fig. S7 Viability of *Chlorella vulgaris* cells by staining an Evans blue dye: (a) dead cells, (b) viable cells, and (c) their viability with time.

Table.S1 Physical parameters used in analytical modeling.

Parameter		Description	Value	Unit
Magnet	B_s	Residual magnetic flux	0.198	T
	W	Magnet width	2×10^{-3}	m
	L	Magnet length	5×10^{-3}	m
Solution	$\emptyset$	Volume fraction of magnetic nanoparticles	1.2	%
	η	Viscosity	9.08×10^{-3}	$Pa \cdot s$
	M_d	Saturation moment of magnetic nanoparticles	4.377×10^{5}	A/m
PS particle	D_p	Particle diameter	$5, 20$	μm
	ρ	Density	1050	kg/m^3
Microchannel	w_c	Channel width	2.54×10^{-4}	m
	h_c	Channel length	5×10^{-5}	m
	Q	Volumetric flow rate	1.39×10^{-11}	m^3/s

Table.S2 Rheological values measured by using CaBER and AR G2.

Samples		η_0 (Pa·s)	η_∞ (10^{-6}Pa·s)	n	λ
0.4 wt% PEO	10 wt% ferrofluid	0.00908	0.721	0.106	0.00713
	15 wt% ferrofluid	0.01099	7840	0.813	0.01136
	20 wt% ferrofluid	0.01557	7550	0.923	0.01266
0.5 wt% PEO	10 wt% ferrofluid	0.0147	7910	0.141	0.00912
	15 wt% ferrofluid	0.01794	13.1	0.171	0.01418
	20 wt% ferrofluid	0.02208	0.355	0.163	0.01807
0.6 wt% PEO	10 wt% ferrofluid	0.018	0.456	0.147	0.00929
	15 wt% ferrofluid	0.02307	26.4	0.162	0.01058
	20 wt% ferrofluid	0.02685	0.215	0.184	0.01387

Movie S1. Particle migration and separation in Newtonian and Viscoelastic fluids.