<u>Supplementary Information</u>

Microsphere sliding on a microtip

Figure S1 shows the sequential images of a microsphere that is sliding on a microtip side and captured at the terminal end of the microtip when the microtip is withdrawn from the solution. The average diameter of the microsphere is 9.00 μm. The red dot in each image indicates the movement of the sphere.

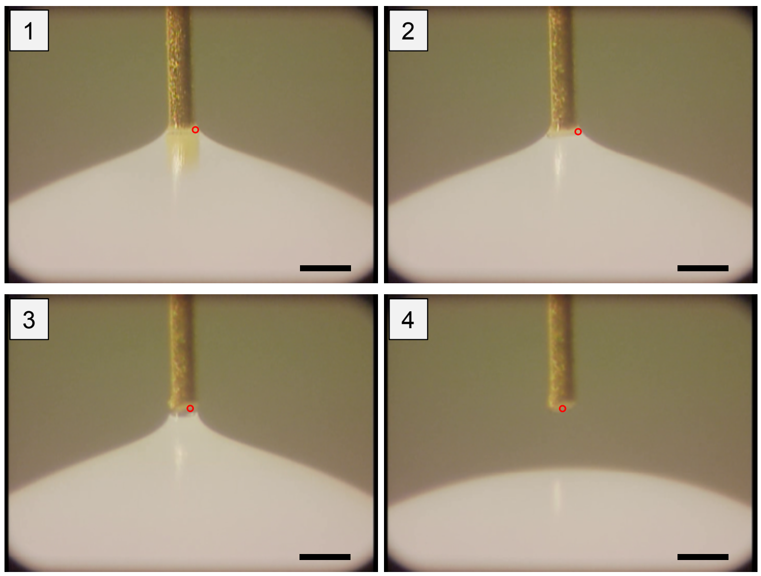
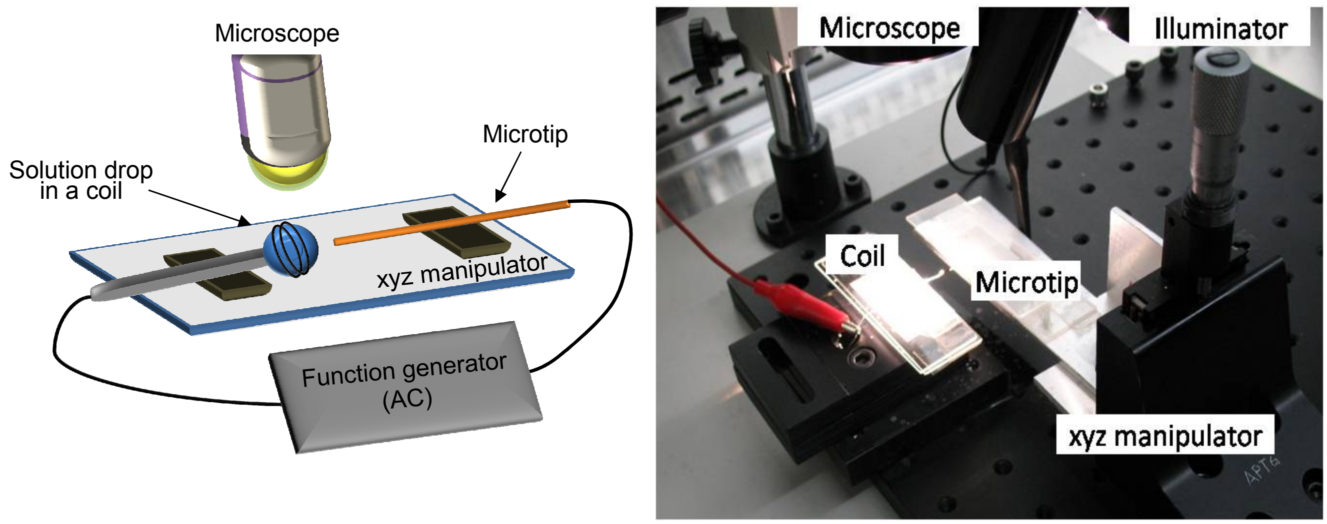


Figure S1. Sequential images (1 → 4) for sphere movement on a microtip surface in a withdrawal step (scale bars: 50 μm).

Experimental setup

Figure S2 shows the configuration of the experimental setup for capturing microspheres and MTB cells by using an AC electric field. After the installation of a gold-plated tungsten microtip (50 μm in diameter, Sylvania, Towanda, PA) and a silver-coated copper coil (250 μm in diameter, OK industries, Tuckahoe, NY), an xyz manipulator was used to control the tip motion. During the experiment, a solution drop was loaded in a coil, and then a microtip was immersed in the drop for 1 minute with an AC electric field (100 kHz at 20 V_{pp}) that was applied between a microtip and a coil.



(A) (B)

Figure S2. (A) Illustration of an experimental setup and (B) Photograph of the experimental setup.

Viscosity measurement

Table S1. Parameters for the viscosity measurement

Parameter	**Value**
Experimental temperature	25 ºC
Shear rate	10^{-3} /s
Geometry	20 mm acrylic plate
Gap	1 mm
Solution volume	300 μL

To measure the local shear viscosity of a suspension, a stress controlled rheometer (AR2000, TA Instruments, New Castle, DE) was used. Microspheres were suspended in DI water at the concentration of 2×10^{8} spheres/mL. In the viscosity measurement, microspheres with 6 different average diameters

(0.95, 2.01, 4.19, 6.02, 9.00, and 18.97 μm from Bangs Laboratories, Inc., Fishers, IN) were used. The experimental conditions are listed in Table S1. At the shear rate of 10^{-3} /s, the measured shear viscosities of the suspension were 52.3±24.2, 50.3±21.9, 82.3±23.4, 37.6±4.7, 108.3±25.9, and 187.0±99.3 Pa·s, respectively. Note that viscosity for each diameter sphere was measured three times and taken the average.

Computation of dielectrophoretic- and releasing capillary forces

Considering a spherical particle, the dielectrophoretic force on a particle is[1]:

$$F_{DEP} = 2\pi r^3 \varepsilon_m \mathrm{Re}[f_{CM}] \nabla |E|^2 \tag{1}$$

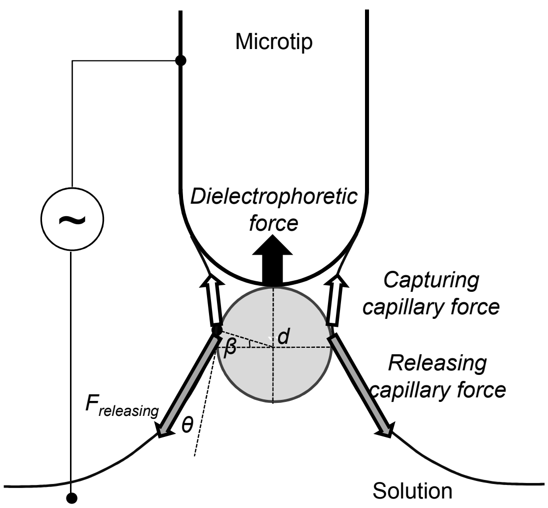
where r is the particle radius, ε_m is the permittivity of the medium, and E is the amplitude of an electric field. $Re[\ ]$ is the real value of f_{CM} , which is the Clausius-Mossotti factor. The dielectrophoretic force is an attractive force to capture the particle. On the other hand, the releasing capillary force acting on a particle tends to retain the particle in the solution. The releasing capillary force from the geometry shown in Figure S3 (A) is:

$$F_{\mathrm{releasing}} = (\pi d \cos(\beta))\gamma \cos(\theta + \beta) \tag{2}$$

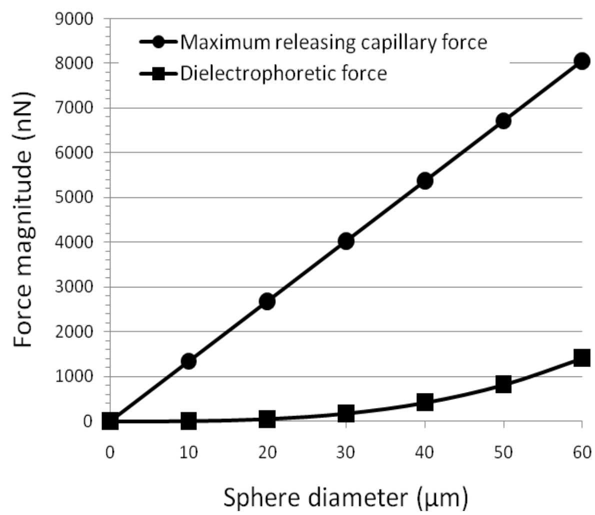
where d is the diameter of the particle, β is the angle between the radial direction to the split point and the horizontal line of the particle, γ is the surface tension coefficient, and θ is the contact angle between the liquid and the particle. The maximum releasing capillary force is:

$$F_{\max} = \pi d \gamma \cos^2(\frac{\theta}{2}) \ \text{,when}\ \beta = -\frac{\theta}{2} \tag{3}$$

This suggests that the capillary force is proportional to a particle diameter, assuming a constant contact angle θ. In equation (1), the dielectrophoretic force was computed by using an axial symmetry model in COMSOL Multiphysics®. The parameters for dielectrophoretic calculations are as follows. The dielectric constant of the medium is 80.1, the dielectric constant of the particle is 2.56, the conductivity of the medium is 0.001 S/m, and the conductivity of the particle is 0.0011 S/m[2]. For the capillary force calculation, the surface tension coefficient is 0.0728 N/m, and the contact angle is ~80°. The computed forces are compared in Figure S3 (B). In the graph, the releasing capillary force is always greater than the DEP force by an order of magnitude. Thus, the particle capturing is dominated by capillary forces on a microtip.



(A)



(B)

Figure S3. (A) Schematic of capillary- and dielectrophoretic force analysis (B) Capillary- and dielectrophoretic forces according to the various diameters of polystyrene spheres.

References

1. Morgan, H.; Green, N. G. *AC Electrokinetics: colloids and nanoparticles*; Research studies press, Baldock, Hertfordshire, England, 2003.

2. Rao, N. N. *Basic electromagnetics with applications*; Prentice-Hall: Englewood Cliffs, NJ, 1972.