Supporting Information

Efficient target capture and transport by fuel-free micromotors in a multichannel microchip

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1. Experimental Section

Preparation details of the magnetic micromotors

Commercial gold plating solution and nickel plating solution (Sichuan Yongan Chemical Co.) were purchased and used as received. 6-Mercaptohexanol,11-mercaptoundecanoic acid, *N*-hydroxysuccinimide, 1-(3-dimethylaminopropyl)-*N'*-ethylcarbodiimide hydrochloride, Concanavalin A, 2-(*N*-morpholino) ethanesulfonic acid, and glycine were purchased from Sigma-Aldrich or Macklin Biochemical Co. Sodium acetate, ethanolamine, $CaCl_2$, and $MnCl_2$ were purchased from Tianjin Yongda Chemical Works, Co. Binding buffer solution (acetate buffer with a pH of 5.0, containing 1 mM Mn^{2+} and 1 mM Ca^{2+}) was obtained from mixing the chemicals mentioned above. The *E. coli* bacteria (ATCC 25922) were obtained from Linyin Tianxing Biological Technology Co.

The micromotors were synthesized by a template method developed by Wang and co-workers.[1,2] Briefly, a porous alumina membrane was employed as a template for electrodeposition. Before Au and Ni plating, the preparatory steps include: sputtering an Ag film on the membrane and electrodepositing Cu into the membrane pores. After that, Au, Ni, and Au were plated onto the membrane in sequence. The Au plating solution, and the nickel plating solution were used at 0.95 V (vs Ag/AgCl) for a charge of 1 C. In the removal process of the templates, the Ag film and deposited Cu were polished by a Al_2O_3 slurry (with a particle size of around 3 μm) and washed by HNO_3 (8 M). Then the Au/Ni/Au micromotors were obtained by immersing the entire

membrane in a NaOH solution (3 M) for 1 h. The micromotors were separated by centrifugation by centrifugation at 5000 rpm for 10 min and washed several times with deionized water.

To selectively capture *E. coli*, the micromotors were functionalized with Concanavalin A, a species of lectin receptors. First, the micromotors were immersed in 11-mercaptoundecanoic acid (0.25 mM) and 6-mercapto-hexanol (0.75 mM) in absolute ethanol for 12 h. The motors were then washed with deionized water, additionally stirred in a 2-(*N*-morpholino) ethanesulfonic acid solution (0.1 M) with *N*-hydroxysuccinimide (20 mM) and 1-(3-dimethylaminopropyl)-*N*'-ethylcarbodiimide hydrochloride (10 mM) for 30 min, and washed with the binding buffer solution for 1 min. Finally, the motors were immersed in the binding buffer solution with Concanavalin A (9 mg/mL) for 2 h to achieve the functionalization. All the steps were performed at room temperature.

SI References

(1) Victor Garcia-Gradilla, Jahir Orozco, Sirilak Sattayasamitsathit, Fernando Soto, Filiz Kuralay, Ashley Pourazary, Adlai Katzenberg, Wei Gao, Yufeng Shen, Joseph Wang. Functionalized Ultrasound-Propelled Magnetically Guided Micromotors: Toward Practical Biomedical Applications. ACS Nano **2013**, *7*, 9232-9240.

(2) Daniel Kagan, Rawiwan Laocharoensuk, Maria Zimmerman, Corbin Clawson, Shankar Balasubramanian, Dae Kang, Daniel Bishop, Sirilak Sattayasamitsathit, Liangfang Zhang, Joseph Wang. Rapid Delivery of Drug Carriers Propelled and Navigated by Catalytic Nanoshuttles. Small **2010**, *6*, 2741-2747.

Batch experiments for capturing *E. coli* by micromotors

For capturing *E. coli* in batch experiments, a mixture of 5–20 μL of the prepared suspension of Au/Ni/Au micromotors (1 × 10^6 motors/mL) and 50 μL of *E. coli* solution (1 × 10^5 cfu/mL) was dropped onto a cleaned glass cell (20 mm × 4 mm × 20 mm) and covered by a coverslide. The capture and transport of *E. coli* depend on the movement of micromotors powered by ultrasound (10V). The direction of the magnetic field was altered every 5 min. After 0.5–1.5 h of movement, a saturated loading was achieved. Then the motors were moved to edges and sampling was performed in the central position. The loading efficiency of was also calculated based on the rate of change of the fluorescence intensity (percentage change in the green area).

Table S1. Acceleration time and motor speeds (of functionalized motors) at different ultrasound transducer voltages.

Voltage (V)	5	10	15	20	25	30
Acceleration time (s)	0.24	0.49	0.70	0.87	1.01	1.12
Motor speed (μm/s)	48	101	122	169	213	255
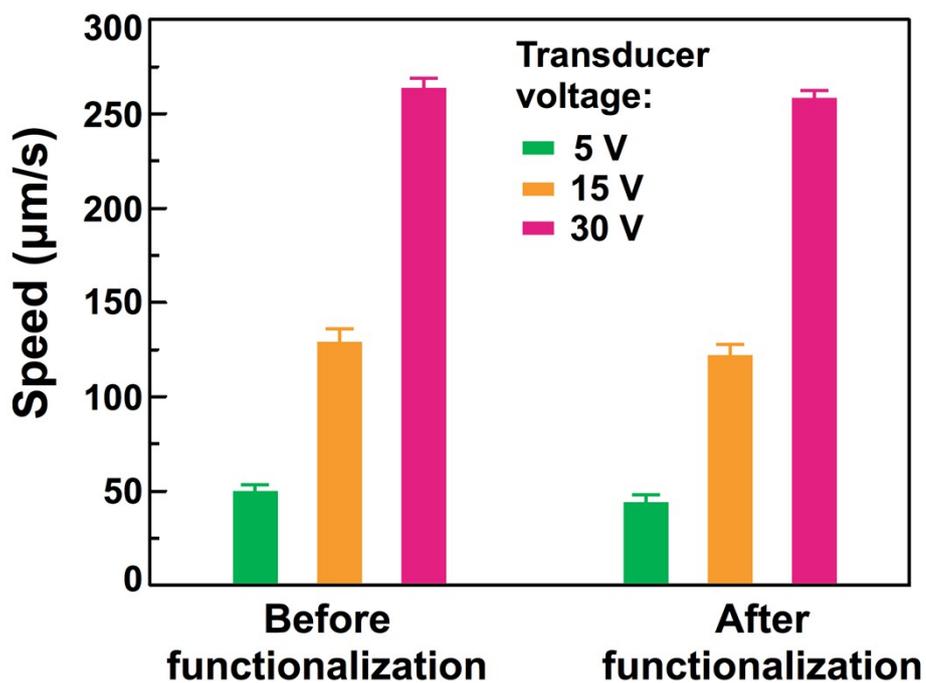
Figure S1. Measurement of motor speeds before and after surface functionalization.
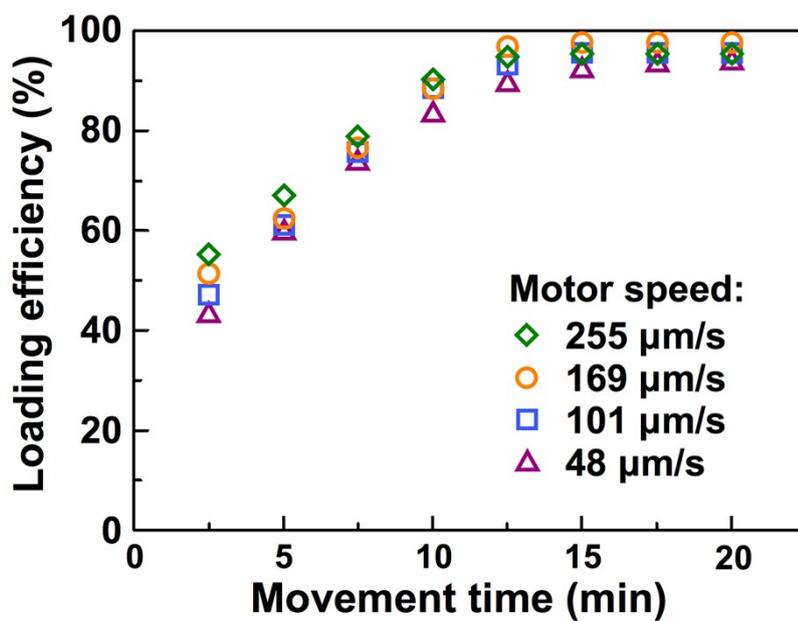
Figure S2. Change of loading efficiencies with time at different motor speeds.
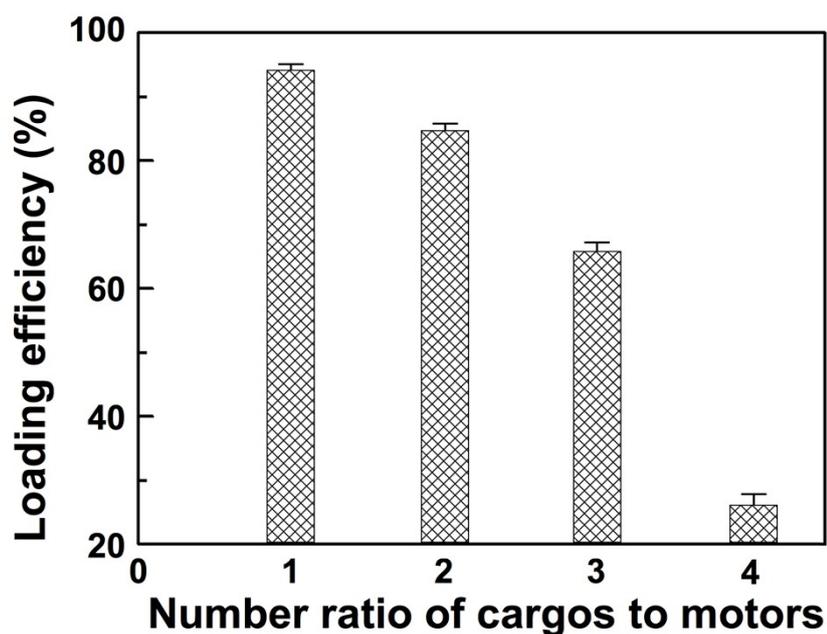
Figure S3. Effects of number ratio of targets to motors and concentrations of *E. coli* on loading efficiencies in batch experiments.

2. Supporting Videos

Videos S1−S4. Capture of cargos (*E. coli* cells) by Au/Ni/Au namomotors at different motor speeds:

  Video S1. Pick-up of one cargo at 101 μm/s.

  Video S2. Pick-up of two cargos at 101 μm/s.

  Video S3. Pick-up of three cargos (*E. coli* cells) at 101 μm/s.

  Video S4. Pick-up of four cargos (*E. coli* cells) at 48 μm/s.

  Video S5. Release of cargos in glycine solution.