Supporting Information

Programmed Transport and Release of Cells by Self-Propelled Micromotors

*Yoshitaka Yoshizumi, Kyohei Okubo, Masatoshi Yokokawa, Hiroaki Suzuki**

Graduate School of Pure and Applied Sciences, University of Tsukuba, 1-1-1 Tennodai, Tsukuba, Ibaraki 305-8573, Japan

*E-mail: hsuzuki@ims.tsukuba.ac.jp

Table of Contents

Supporting Information Videos.

Video S1. Zn/Pt micromotors moving in 100 mM aqueous methanol solution for 5 min under the condition used in Figure 2A (left).

Video S2. Zn/Ni/Pt micromotor moving in a 100 mM aqueous methanol solution in presence and absence of a magnetic field for 4 min. The motor used was the same as the one in Figure 4B.

Video S3. Zn/Pt/SAM micromotor with *E. coli* moving in a 100 mM aqueous methanol solution for 5 min. The motor used was the same as the one in Figure 7A,B. The trajectory of the Zn/Pt micromotor is shown in the same video, which was modified to run at a speed of 20× compared to real time.

Estimation of the Micromotor Running Time. The running time, T, of the motor is determined by the reaction $Zn \rightarrow Zn^{2+} + 2e^-$ and estimated from the equation $T = 2N_{Zn}/n_e$. Here, N_{Zn} and n_e are the mole number of zinc on a Zn/Pt micromotor and the mole number of electrons per unit time, respectively. N_{Zn} is calculated to be 5.1×10^{-13} mol using the motor radius (2.5 μm), zinc layer thickness (300 nm) and density (7.14 g/cm^3), and the atomic weight (65.4) of zinc. A value of 1.6×10^{-18} mol/s is obtained for n_e from the current density in Figure 2B (~1×10^{-6} A/cm^2), zinc surface area ($2\pi(2.5 \times 10^{-4})^2$ cm^2), and the Faraday constant (9.65×10^4 C/mol). From these values, $T = 6.4 \times 10^5$ s or ~180 h.

Relaxation Time of Micromotor Inertial Motion. The relaxation time τ is obtained from the equation $m(\mathrm{d}^2x/\mathrm{d}t^2) = -6\pi\eta a\,(\mathrm{d}x/\mathrm{d}t)$ and is given by $\tau = 2a^2\rho/(9\eta)$, where a, ρ, m, and η are the radius, density, and mass of the motor, and the dynamic viscosity of the solution, respectively. The glide distance $L = \tau v_0\,(1 - 1/\mathrm{e})$ is then calculated using a typical initial velocity of $v_0 = 1.0$

μm/s, a = 2.5 μm, m = 2.5 × 10^{-13} kg, calculated from the densities of polystyrene (1.05 g/cm^3), platinum (21.5 g/cm^3), gold (19.3 g/cm^3), nickel (8.90 g/cm^3), and zinc (7.14 g/cm^3), and the layers of platinum, gold, nickel (50 nm thick each), and zinc (300 nm thick), and η = 0.890 × 10^{-3} Pa s. From these values, L = 3.7 × 10^{-12} m.

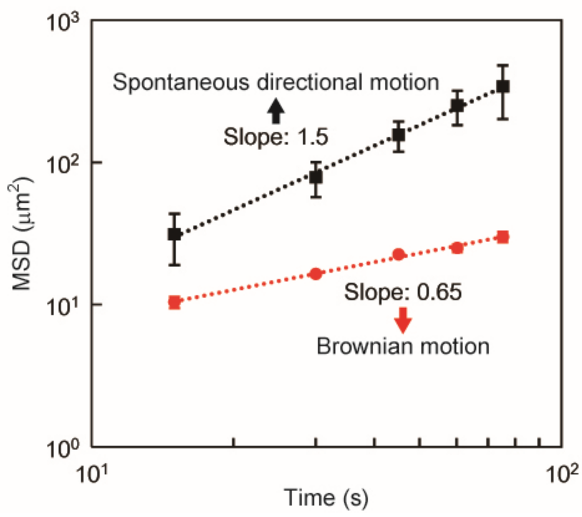

Figure S1. Double logarithmic plot of Figure 3. MSD values of the Zn/Pt micromotors (solid black squares) and the Au/Pt beads (solid red circles) in 100 mM aqueous methanol solution are plotted against time. The error bars are standard deviations and correspond to those in Figure 3.

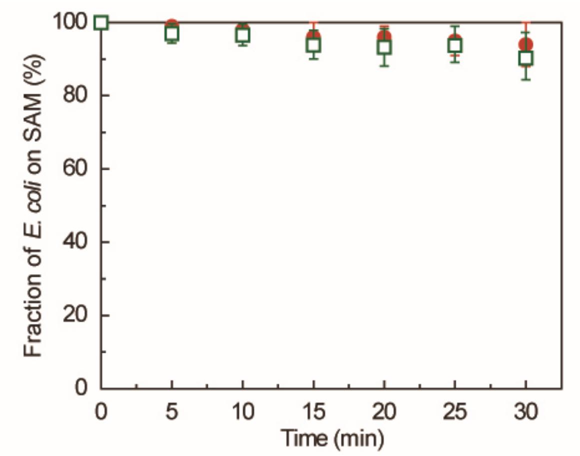

Figure S2. Influence of methanol on the release of *E. coli* from the Zn/Pt/SAM composite planar electrode. The number of residual *E. coli* cells on the surface was counted every 5 min after changing the phase to 1.0 mM aqueous $ZnCl_2$ solution (solid red circles) and 1.0 mM $ZnCl_2$/100 mM methanol aqueous solution (open green squares). The solid red circles in this figure correspond to the ones in Figure 6C. Averages and standard deviations are shown (n = 5).

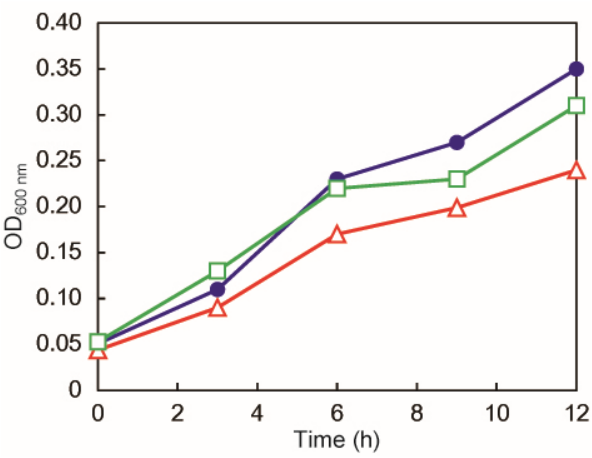

Figure S3. Growth curves of *E. coli* after immersion in 100 mM aqueous methanol solution (open red triangles), culture medium (control, solid blue circles), and 1.0 mM aqueous $ZnCl_2$ solution (open green squares) for 1 h at room temperature. Culturing was conducted at 37 °C, and the initial concentration of *E. coli* was adjusted to an OD_{600} of 0.05 by dilution with PBS before the OD measurements.

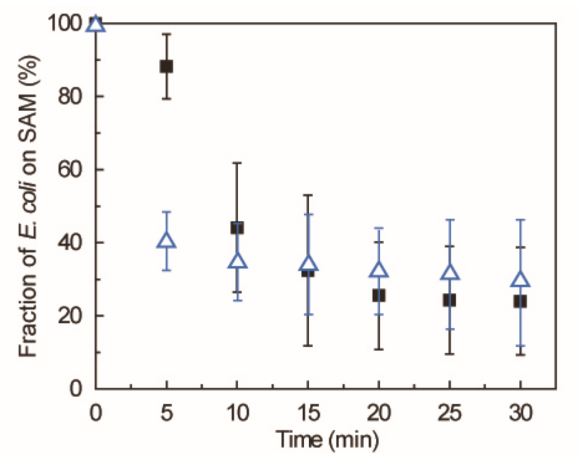

Figure S4. Ratio of residual *E. coli* cells on a planar platinum electrode modified with 1-decanethiol (solid black squares) and 1-hexanethiol (open blue triangles). The solid black squares in this figure correspond to the ones in Figure 6C. Averages and standard deviations are shown (n = 5).