SUPPLEMENTARY INFORMATION

Material-dependent performance of fuel-free, light-activated, self-propelling colloids

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EXPERIMENTAL PROCEDURES

1. Particle fabrication

SiO_2 microspheres of 3.17μm in diameter were obtained from Bangs Laboratories, Inc. (Fishers, Indiana). The particles are first rinsed several times in DI water before the water is replaced by pure ethanol (~500μL). The microspheres were then made hydrophobic with the addition of ~250 μL of (3-aminopropyl) triethoxysilane (APTES): 99% Sigma-Aldrich. Via a Langmuir-Blodgett method, a close-packed monolayer was transferred from the surface of DI water to a silicon wafer.

We utilize a glancing angle deposition vacuum system in which physical vapor impinges onto the surface containing the microspheres at an angle. Due to the "shadowing effect" the material deposits onto the tops of the spheres. In order to obtain a uniform distribution of the TiO_2 (Kurt J. Lesker (Jefferson Hills, Pennsylvania) during the deposition, the substrate was rotated steadily about an axis parallel to the substrate surface normal. After the deposition, the entire substrate was annealed for ~2 hours.

Experimental parameters: Amount of material deposited: **~2μm of TiO_2**

Deposition angle: **85°**

Vacuum pressure: **~10^{-6}Torr**

Annealing temperature: **500°C for 2 hours**

The final fabrication step involves the deposition of the Au/Pd alloy onto the tops of the particles. Different amounts of the alloy were sputtered with a Denton Vacuum Desk II. TEM images of the final product are shown in Figure S1.

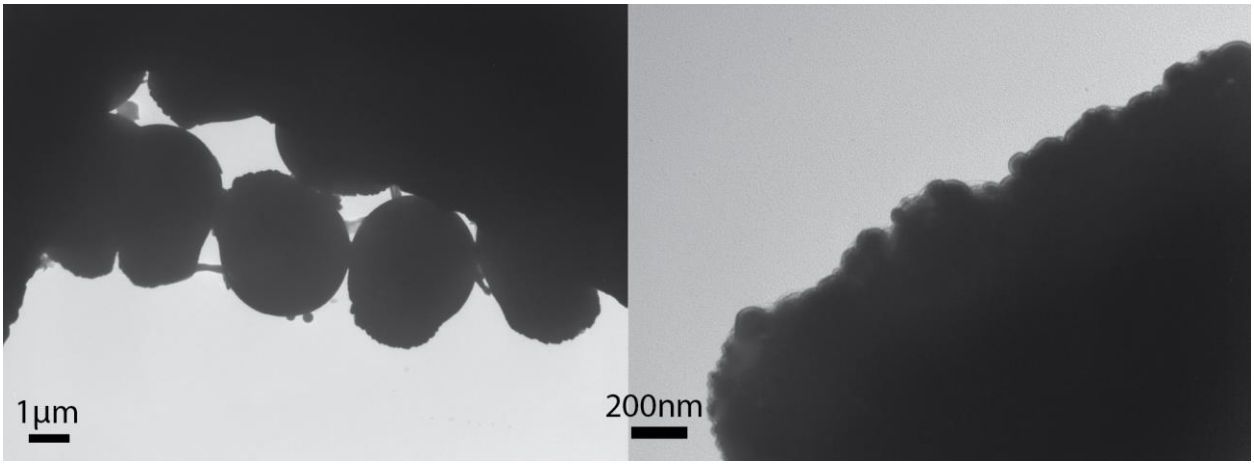

Figure S1. TEM images of the active particles (10nm thickness of the Au/Pd alloy).

2. Sample preparation

The entire substrate containing the fabricated active particles, which consist of both TiO_2 and the Au/Pd alloy, were submerged in DI water and subjected to bath sonication to remove the particles from the surface and create a colloidal suspension.

In order to observe the dynamics of the particles, a cell was constructed by removing a square segment from a piece of double-sided tape. The tape was adhered to a previously cleaned glass microscope slide. We used a hydrophobic pen to form a barrier between the center of the cell and the tape's edge to prevent the fluid from escaping the cell. The colloid was pipetted onto the bottom of the cell, which was then sealed with a clean cover slide. The colloidal droplet was then subjected

to UV light (λ= 365 nm) and at a maximum possible intensity for our equipment (Zeiss AxioScope.A1 fluorescence microscope): ≈600 mW cm^{-2}.

3. Obtaining raw data

Videos of the particles in action were recorded at ~15fps (Thorlabs DCU223 CCD).

4. **Data processing**

Particle tracking was performed with the software *ImageJ*. The plugin returns 2D trajectories of the particles in terms of *x* and *y* positions in a plane. These positions were converted to real-space dimensions in micrometers. Afterward, the mean-squared displacement (MSD) was calculated. For a fixed lag time, Δt, this quantity is given by

$$MSD = \langle|\Delta r(\Delta t)|^2\rangle = \frac{1}{n-1}(|\Delta r_1(\Delta t)|^2 + |\Delta r_2(\Delta t)|^2 + \cdots) = \frac{1}{n-1}\sum_{i=1}^{n-1}|\Delta r_i(\Delta t)|^2. \quad (1)$$

The MSD for active Janus spheres is given by

$$\langle|\Delta r(\Delta t)|^2\rangle = 4D\Delta t + \frac{1}{2}v^2\tau_R^2\left(\frac{2\Delta t}{\tau_R} + e^{-2\Delta t/\tau_R} - 1\right). \quad (2)$$

We determine the speed by simplifying Eq. (2) with the approximation $\Delta t \ll \tau_R$

$$\langle|\Delta r(\Delta t)|^2\rangle = 4D\Delta t + v^2\Delta t, \quad (3)$$

or the time lag is much shorter than the rotational diffusion time

$$\tau_R = \frac{8\pi\eta R^3}{k_B T} \quad (4)$$

where η is the viscosity, and $R = a/2$ is the radius of a (spherical) particle. By fitting the calculated MSD for short times to Eq. (3), the speed *v* drops out as a fitting parameter.