Electronic Supplementary Material (ESI) for Soft Matter.

Supporting Information

Janus Dendritic Silica/Carbon@Pt Nanomotors with Multiengines for H_2O_2, Near-Infrared Light and Lipase Powered Propulsion

Yi Xing, Xin Du*, Tailin Xu*, and Xueji Zhang*

Research Center for Bioengineering and Sensing Technology, Beijing Key Laboratory for Bioengineering and Sensing Technology, Department of Chemistry & Biological Engineering, University of Science & Technology Beijing, Beijing 100083, China

*Corresponding Authors

E-mail addresses: duxin@ustb.edu.cn; xutailin@ustb.edu.cn; zhangxueji@ustb.edu.cn

SUPPORTING METHODS

Regents

Tetraethyl orthosilicate (TEOS, ≥ 99%), 3-aminopropyltriethoxysilane (APTES, ≥ 98%), triethanolamine (TEA, ≥99%), cetyltrimethylammonium tosylate (CTAT, ≥98%), potassium tetrachloroplatinate (II) (K_2PtCl_4) and lipase (from Candida Rugose, Type VII, ≥ 700 unit/mg solid) were purchased from Sigma Aldrich. Concentrated hydrochloric acid (HCl, 37%), resorcinol, formaldehyde (37.0~40.0%), glycerol triacetate, and absolute ethanol (99.5%) were purchased from Beihua Fine Chemicals. Phosphate buffered saline (PBS) was obtained from Thermo Fisher Scientific Ltd. Hydrogen peroxide (H_2O_2, 30 wt%) was purchased from Aladdin. Ultrapure water with a resistivity higher than 18.2 MΩ·cm was used in all experiments and was obtained from a three-stage Millipore Mill-Q Plus 185 purification system (Academic).

Morphology and structure characterization.

For transmission electron microscopy (TEM) observations, powder samples were added on carbon-coated copper grids and observed on a Hitachi HT-7700 transmission electron microscope at an acceleration voltage of 100 kV. Scanning electron microscopy (SEM) observations were carried out on a Hitachi S-8010 scanning electron microscope operated at 10 kV. Specimens were coated with a layer of gold with a size of 5 nm by ion sputtering before SEM observations.

Motion characterization of Janus nanomotors.

H_2O_2-motivated motion: The H_2O_2 solutions with different mass fractions ranging from 2 % to 6 % were previously prepared and used as chemical fuels. Janus DMS/RF@Pt nanomotors (dispersed in 10 μL of DI water) and as-prepared H_2O_2 solutions (10 μL) were firstly mixed in a 2 mL capped vial. After uniform mixing, the mixture was added into a groove (5 mm of diameter, 0.5 mm of thickness) on the quartz slide (2 mm thickness) and sealed with a high-clean cover glass (8 mm diameter) to avoid environmental disturbances.

NIR light-driven motion: DMS/RF@Pt nanomotors in 10 μL of DI water was added

into a groove (5 mm of diameter, 0.5 mm of thickness) on the quartz slide (2 mm of thickness) and sealed with a high-clean cover glass (8 mm of diameter) to avoid environmental disturbances. A 980-nm fiber-coupled diode laser system was used to provide a gradient NIR light irradiation to trigger the nanomotors. A beam expander (2 cm of diameter) was installed at the laser source, which was inclined to the quartz slide with an angle of 45° and evenly irradiated the groove.

Lipase-powered motion: The triacetin solutions with different concentrations from 2 to 20 mM were previously prepared and used as chemical fuels. Janus DMS/RF@Pt nanomotors (dispersed in 10 μL of DI water) and as-prepared triacetin solutions (10 μL) were firstly mixed in a 2 mL capped vial. After uniform mixing, the mixture was added into a groove (5 mm of diameter, 0.5 mm of thickness) on the quartz slide (2 mm thickness) and sealed with a high-clean cover glass (8 mm diameter) to avoid environmental disturbances.

All the imaging experiments were recorded at a rate of 9-12 frames per second using a Nikon-U upright microscope, which was equipped with a 100 W halogen tungsten lamp, a 40 X/20 X plan fluor objective and a DS-Ri2 microscope camera. ImageJ and its plug-in (MTrackJ) were conjunctively used to analyze the motion of nanomotors.

SUPPORTING FIGURES

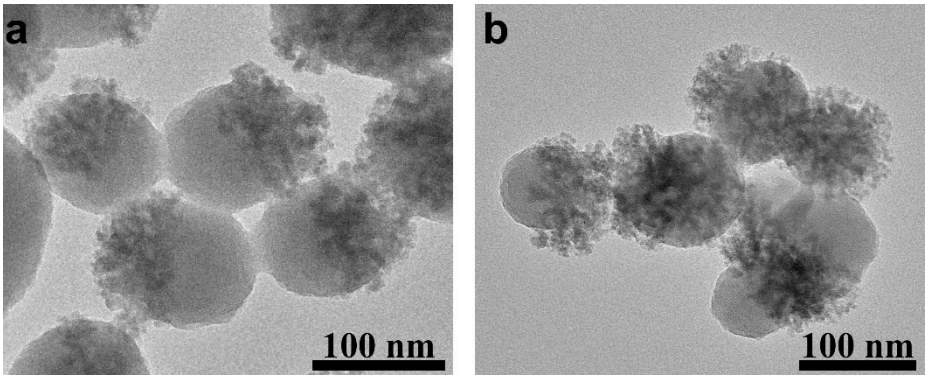

Fig. S1 TEM images of (a, b) Janus DMS/RF@Pt nanoparticles before carbonization.

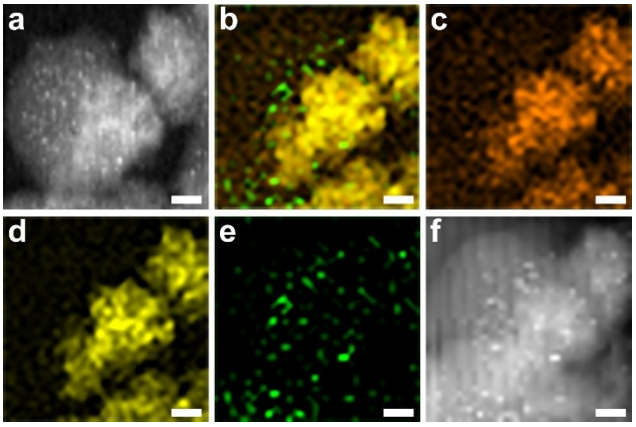

Fig. S2 (a) STEM images of Janus DMS/C@Pt nanoparticles. EDX mapping analyses of (b) merge, (c) O, (d) Si, (e) Pt. (f) Spectrum image after scanning.

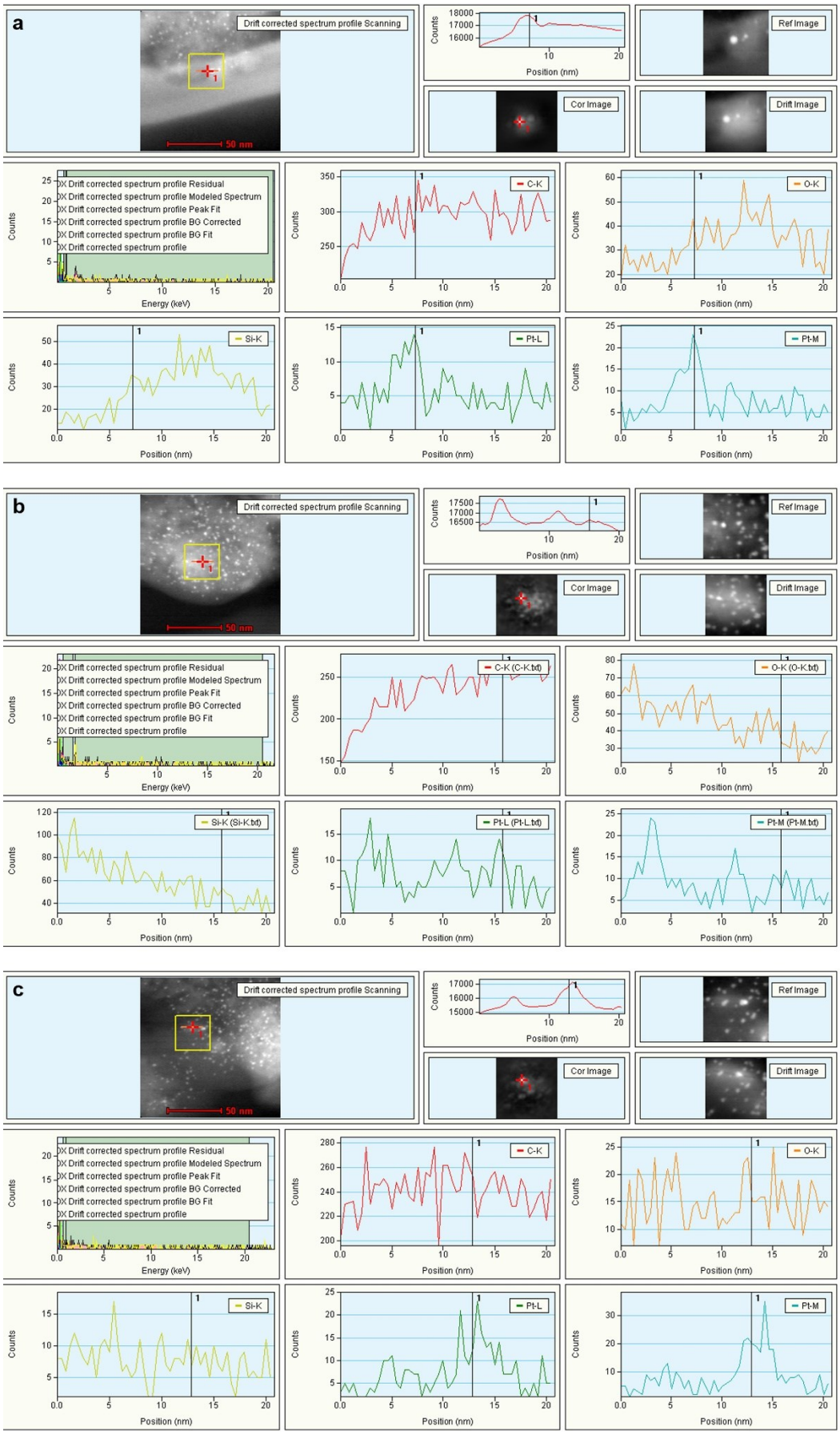

Fig. S3 (a-c) EDX analyses by line scan.

SUPPORTING VIDEOS

Video S1. Representative motion movie of Janus DMS/C@Pt nanomotors in the 3 % H_2O_2 solution and corresponding Brownian motion in the absence of H_2O_2.

Video S2. Representative motion movie of Janus DMS/C@Pt nanomotors upon the NIR laser (980 nm, 1.0 W/cm^2).

Video S3. Comparative motion movie of Janus LDMS/C@Pt nanomotors in the 1 and 10 mM triacetin solutions.