Supporting Information to the paper

Alignment of Tellurium Nanorods *via* a Magnetization-Alignment-Demagnetization ("MAD") Process Assisted by an External Magnetic Field

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1. Mössbauer spectrum of the magnetite nanoparticles

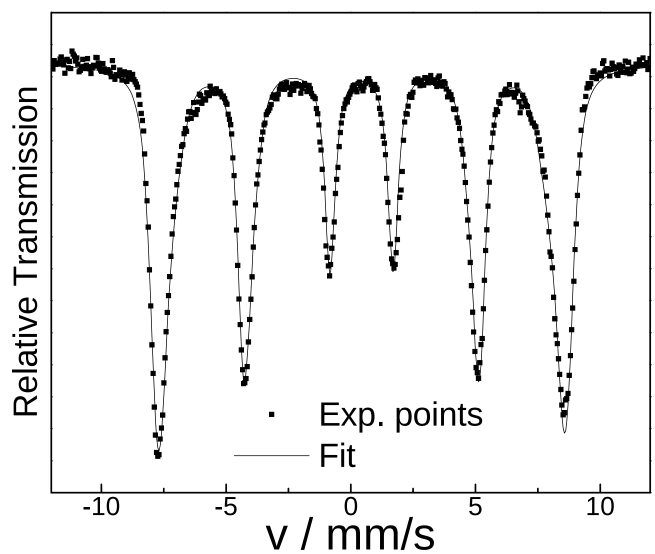

Figure s-1. ^{57}Fe Mössbauer spectrum of the magnetite nanoparticles. The spectra were recorded using a constant-acceleration conventional spectrometer and a helium bath cryostat. The partly resolved two sextets at 85 K confirm the phase to be magnetite Fe_3O_4.

2. Details of Te (2) and Te (3) nanorods and their assembly with magnetite nanoparticles

Beside Te (1), the Te (2) and Te (3) nanorods were also used for the synthesis of magnetic nanocylinders to verify this robust strategy. Fig. s-2A shows the TEM image of Te (2) nanorods before

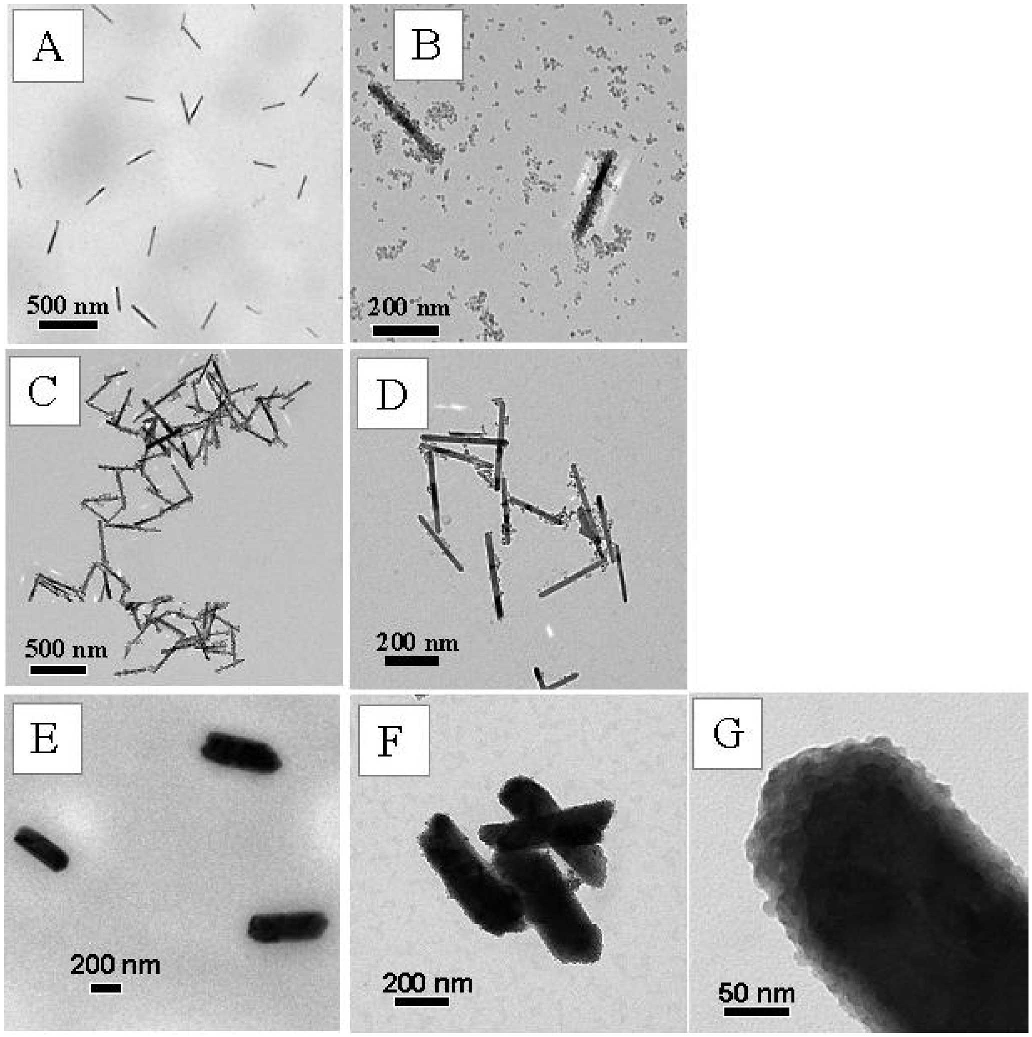

Figure s-2. (A), TEM image of Te (2) nanorods; (B)-(D), magnetic Te (2) nanocylinders formed by Te (2) nanorods (33.7 mg/L) and different concentrations of magnetite nanoparticles: (B) 25 mg/L, (C) 8.65 mg/L, and (D) 2.15 mg/L in THF; (E), TEM image of Te (3) nanorods; (F), magnetic nanocylinders formed by Te (3) nanorods (71 mg/L) and magnetite nanoparticles (1.8 mg/L) at the critical concentration; and (G), enlarged view of the magnetic Te (3) nanocylinders at the critical concentration.

decorated with nanoparticles. The average length and diameter are 295 ± 47 nm and 21 ± 5 nm (aspect ratio = 14). When magnetite nanoparticles were added into the Te (2) nanorod solution above the critical concentration (here defined as 8.65 mg/L), the nanoparticles are found everywhere in the TEM grid (Fig. s-2B). At the critical concentration, as shown in Fig. s-2C, all nanoparticles stick on the Te nanorods and leave no free nanoparticle in the solution. Through the calculation, the population of nanoparticles per nanorod here is 69 (253 by theoretical calculation, see following Supporting Information). Below the critical concentration, less nanoparticles are attached on the Te nanorods, as shown in Fig. s-2D (only 17 nanoparticles per Te nanorod by calculation).

The Te (3) nanorods with a rather low aspect ratio of 3 are shown in the TEM image in Fig. s-2E. They also show the ability of assembling magnetite nanoparticles. The magnetic Te (3) nanocylinders at the critical concentration are shown in the TEM image in Fig. s-2F. Each nanocylinder contains 597 nanoparticles (2121 by theoretical calculation, see following Supporting Information). Fig. s-2G shows its enlarged view, where the dense nanoparticles are clearly visible on the nanorod edge.

3. Calculation of the population of magnetite nanoparticles per Te nanorod according to their concentrations in THF.

In order to simplify the calculation, several assumptions are made as follows.

(1) Both Te nanorods and magnetite nanoparticles are considered as rigid objects regardless of polymer or surfactant on their surface.

(2) The Te nanorods and magnetite nanoparticles are considered uniform. The dimensional parameters, like radius and length, are taken from their average values. The polymer layer on Te nanorods and the oleic acid layer on magnetite nanoparticles are neglected with regard to the weight.

The mass of individual Te nanorod is expressed as below:

$$m_{Te,NR} = \rho_{Te} \cdot V_{Te,NR} = \rho_{Te} \cdot \pi \cdot R_{Te,NR}{}^{2} \cdot L_{Te,NR} \qquad (1)$$

$m_{Te,NR}$: Mass of a single Te nanorod

ρ_{Te}: Density of tellurium at 25 °C, 6.24 g/cm^3.

$V_{Te,NR}$: Volume of a single Te nanorod

$R_{Te,NR}$: Radius of the Te nanorod section

$L_{Te,NR}$: Length of the Te nanorod

The mass of a single nanoparticle is expressed as below:

$$m_{Fe_3O_4,NP} = \rho_{Fe_3O_4} \cdot V_{Fe_3O_4,NP} = \rho_{Fe_3O_4} \cdot \frac{4}{3} \cdot \pi \cdot R_{Fe_3O_4,NP}{}^3 \qquad (2)$$

$m_{Fe_3O_4,NP}$: Mass of a single magnetite nanoparticle

$\rho_{Fe_3O_4}$: Density of magnetite at 25 °C, 5.1 g/cm^3.

$V_{Fe_3O_4,NP}$: Volume of a single magnetite nanoparticle

$R_{Fe_3O_4,NP}$: Radius of the magnetite nanoparticles

The population of nanoparticles per nanorod is calculated from the equation below.

$$\begin{aligned} n_{real} &= \frac{N_{Fe_3O_4,NP}}{N_{Te,NR}} = \frac{\dfrac{M_{Fe_3O_4,NP}}{m_{Fe_3O_4,NP}}}{\dfrac{M_{Te,NR}}{m_{Te,NR}}} \\ &= \frac{M_{Fe_3O_4,NP}}{M_{Te,NR}} \cdot \frac{m_{Te,NR}}{m_{Fe_3O_4,NP}} \\ &= \frac{C_{Fe_3O_4,NP}}{C_{Te,NR}} \cdot \frac{\rho_{Te} \cdot \pi \cdot R_{Te,NR}{}^2 \cdot L_{Te,NR}}{\rho_{Fe_3O_4} \cdot \frac{4}{3} \cdot \pi \cdot R_{Fe_3O_4,NP}{}^3} \\ &= \frac{C_{Fe_3O_4,NP}}{C_{Te,NR}} \cdot \frac{\rho_{Te} \cdot R_{Te,NR}{}^2 \cdot L_{Te,NR}}{\rho_{Fe_3O_4} \cdot \frac{4}{3} R_{Fe_3O_4,NP}{}^3} \qquad (3) \end{aligned}$$

$N_{Fe_3O_4,NP}$: Total population of magnetite nanoparticles.

$N_{Te,NR}$: Total population of Te nanorods.

$M_{Fe_3O_4,NP}$: Mass of all magnetite nanoparticles.

$M_{Te,NR}$: Mass of all Te nanorods.

$C_{Fe_3O_4,NP}$: Concentration of magnetite nanoparticles in THF.

$C_{Te,NR}$: Concentration of Te nanorods in THF.

Table s-1. Population of magnetite nanoparticles per Te nanorod according to their concentrations in THF.

	Fig. 2C	Fig. 2D	Fig. 2E	Fig. s-2D	Fig. s-2F
$C_{Te,NR}$ (mg /L)	60	60	33.7	33.7	71
$C_{Fe_3O_4,NP}$ (mg /L)	5.2	1.87	8.65	2.15	1.8
$R_{Te,NR}$ (nm)	23.45	23.45	10.5	10.5	77.5
$L_{Te,NR}$ (nm)	422	422	295	295	473
n_{real}	167	60	69	17	597

4. Calculation of the population of nanoparticles per Te nanorod by monolayer close-packing from their dimension.

The assumptions here are made as follows.

(1) Both Te nanorods and magnetite nanoparticles are considered as rigid objects.

(2) The Te nanorods and magnetite nanoparticles are considered uniform. The dimensional parameters, like radius and length, are taken from their average values, except in the case of magnetite nanoparticles, the radius is set to 5.8 nm (1 nm thickness of oleic acid layer) since the layer of oleic acid on their surface cannot be neglected in solution with regard to the volume.

In Fig. s-3C, the following equation is valid,

$$\sin\frac{\alpha}{2} = \frac{R_{Fe_3O_4,NP}}{R_{Te,NR} + R_{Fe_3O_4,NP}}$$

$$\alpha = 2\cdot\arcsin\left(\frac{R_{Fe_3O_4,NP}}{R_{Te,NR} + R_{Fe_3O_4,NP}}\right)$$

In Fig. s-3E, the d is calculated from the Pythagorean theorem

$$d = \sqrt{(R_{Fe_3O_4,NP} + R_{Fe_3O_4,NP})^2 - R_{Fe_3O_4,NP}{}^2} = \sqrt{3}R_{Fe_3O_4,NP}$$

The population of nanoparticles per Te nanorod can be calculated from the equation below.

$$n_{theo.} = \frac{2\pi}{\alpha}\cdot\frac{L_{Te,NR}}{d}$$

$$= \frac{2\pi}{2\cdot\arcsin\left(\frac{R_{Fe_3O_4,NP}}{R_{Te,NR} + R_{Fe_3O_4,NP}}\right)}\cdot\frac{L_{Te,NR}}{\sqrt{3}R_{Fe_3O_4,NP}}$$

Table s-2. Population of nanoparticles per Te nanorod by monolayer close-packing from their dimension.

	Te (1)	Te (2)	Te (3)
$R_{Fe_3O_4,NP}$ (nm)	5.8	5.8	5.8
$R_{Te,NR}$ (nm)	23.45	10.5	77.5
$L_{Te,NR}$ (nm)	422	295	473
$n_{theo.}$	660	253	2121

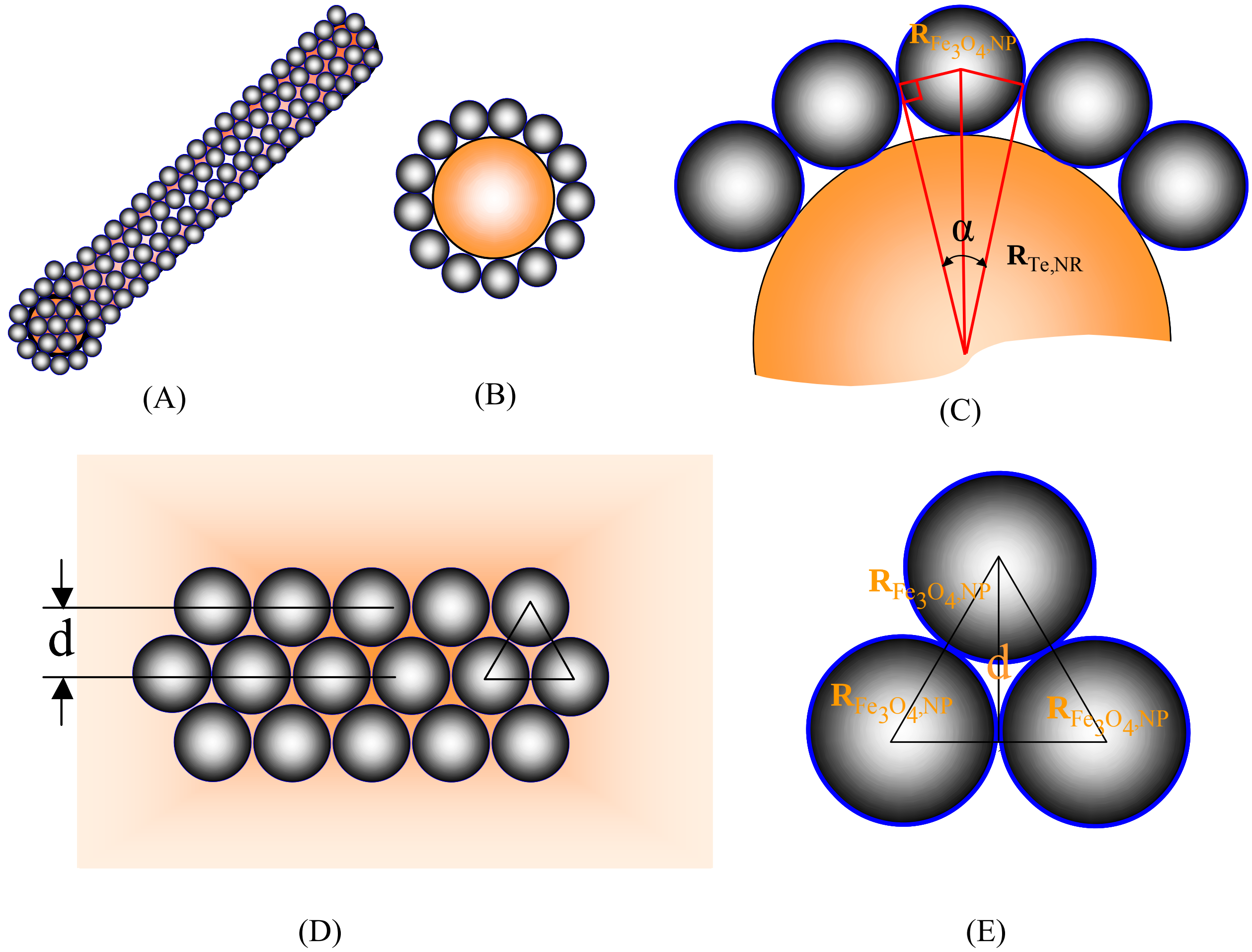

Figure s-3. (A) Illustration of magnetic nanocylinders with monolayer of magnetite nanoparticles close-packed on a single Te nanorod. (B) Cross-section view of the magnetic nanocylinders. (C) Mathematic relation between the cross-sections of the nanoparticles and the Te nanorod. (D) Vertical view of monolayer close-packing of nanoparticles on Te nanorod surface. (E) Mathematic relation between the monolayer of nanoparticles closed packed on the Te nanorod surface.

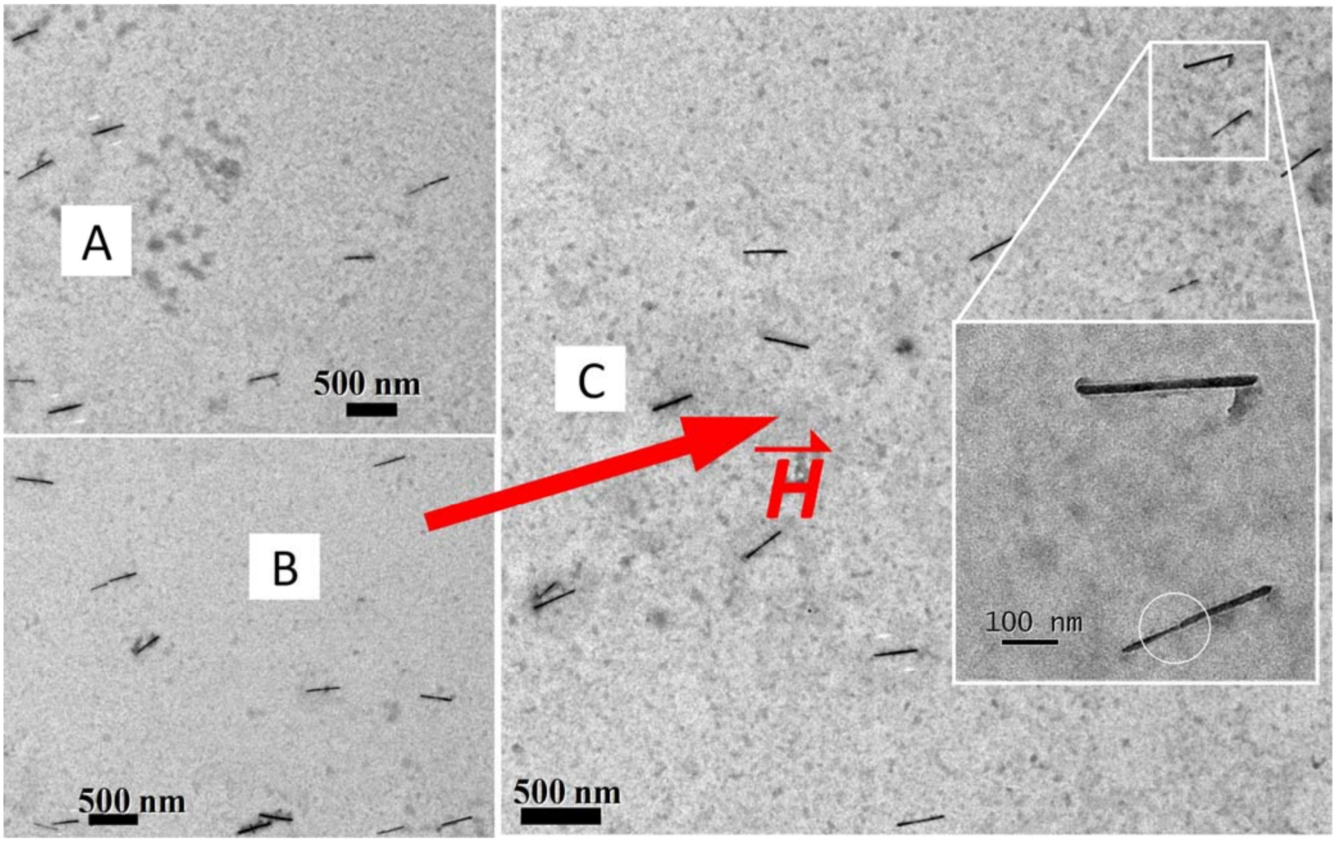

Figure s-4. (A)-(C), TEM images of aligned Te (2) nanorods on the carbon-coated TEM grid after the complete etching of magnetite nanoparticles from the nanorod surface in aqueous HCl solution (80 min). The inset in (C) is an enlarged view of two nanorods; the white circle indicates a slightly deformed area (thinner diameter) of a nanorod after etching due to the corrosiveness of HCl.