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Supplementary Materials

Scalable and Continuous Preparation of Nano-stirbars by Electrospinning

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1. Experimental section

Materials: All chemicals are reagent grade and used as purchased without further purification or adjustments. Polyacrylonitrile (PAN, Mw=150000), iron (III) acetylacetonate, 4-mercaptobenzoic acid (4-MBA, 90%), 4-nitrophenol (4-NP), borohydride ($NaBH_4$), hydroquinone (HQ) and 3-aminopropyltriethoxysilane (APTES) were all purchased from Sigma-Aldrich. Oleic acid and benzyl ether were purchased from Aladdin; hexadecyltrimethylammonium bromide (CTAB) form Sigma; N, N'-dimethylformamide (DMF) and ethanol (EtOH) from Sinopharm Chemical Reagent Co. Ltd; and hydrogen tetrachloroaurate (III) trihydrate (HAuCl4, 99.9%, Au 49% on metals basis) from Alfa Aesar. Copper specimen grids (300 mesh) with formva/carbon support film were purchased from Beijing Zhongjingkeyi Technology Co. Ltd. Deionized water (resistance > 18.2 $M\Omega\bullet cm^{-1}$) was used in all reactions.

Fabrication of Fe_3O_4 Magnetic Nano-stirbars: The Fe_3O_4/PAN precursor magnetic nanofibers were prepared via an electrospinning method. First, Fe_3O_4 nanoparticles (110 nm) were synthesized according to the reported work with minor modification. More specifically, iron (III) acetylacetonate (0.71 g) was mixed with oleic acid (1.2 g) and benzyl ether (10 ml) with N_2 degasing for 1 h. The mixture was heated to 320 ℃ and kept at this temperature for 30 min. After cooling to room temperature, the product was washed in DMF and isolated by magnetic attraction before use. The electrospun precursor was prepared by adding 1 mL as-synthesized Fe_3O_4 into 1.5 mL of PAN (13 wt%) DMF solution. It was vigorous stirred until uniform. Subsequently, the homogeneous solution was loaded into a syringe pump and electrospun by applying 13 kV with the pump feeding rate of 0.1 mm min^{-1} at an electrode distance of 20 cm. At first, a rotary drum was used as the counter electrode to collect the Fe_3O_4/PAN nanofibers. The collected nanofiebr film was peeled off and transferred into the water ultrosonic bath. After 1.5 h, Fe_3O_4/PAN nano-stirbars were obtained. For the continuous fabrication of nano-stirbars, nanofibers were electrospun directly into the water both with the counter electrode immersed in it. The extral ultrosonic tip was plunged into the water. The Fe_3O_4/PAN nano-stirbars were formed while electrospinning simultaneously.

Preparation of Nano-stirbars with Au Nanowires: The growth Au nanowires process was carried out according to a reported method. Nano-stirbars were pretreated with O_2 plasma for 10 min to improve its surface hydrophilicity. The nano-stirbars were then functionalized with an amino group by reacting with APTES solution (5 mM) for 30 min. Subsequently, the nano-stirbars were soaked in excess citrate-stabilized Au seeds (3-5 nm) solution for 2 h to ensure the adsorption of Au seeds and rinsed with water twice to remove the excess Au seeds. The seed-adsorbed nano-stirbars were then immersed in a reaction solution containing the ligand MBA (550 μM), $HAuCl_4$ (1.7 mM), and Hydroquinone (4.1 mM) for 15 min. Finally, the nano-stirbars were isolated by centrifugation and rinsed with water.

Catalytic Performance of Hydrogenation of 4-nitrophenol Using the Au-loaded Nano-stirbars: 2.0 mL $NaBH_4$ (0.04 mM), 2.0 mL 4-nitrophenol (4 mM) were mixed well. 1 μg of the nano-stirbars loaded with Au nanowires were added into the mixed solution. The reaction process was recorded with UV-Vis at 1 min interval.

Characterizations: TEM images were collected from a Talos L120C model Transmission Electron Microscopy operated at 120 kV. Field emission scanning electron microscope (SEM) images were collected on a FEI Quanta 250 FEG model. UV-Vis spectra were collected on a Lambd 750 UV-Vis spectrophotometer.

2. Supplementary figures and videos.

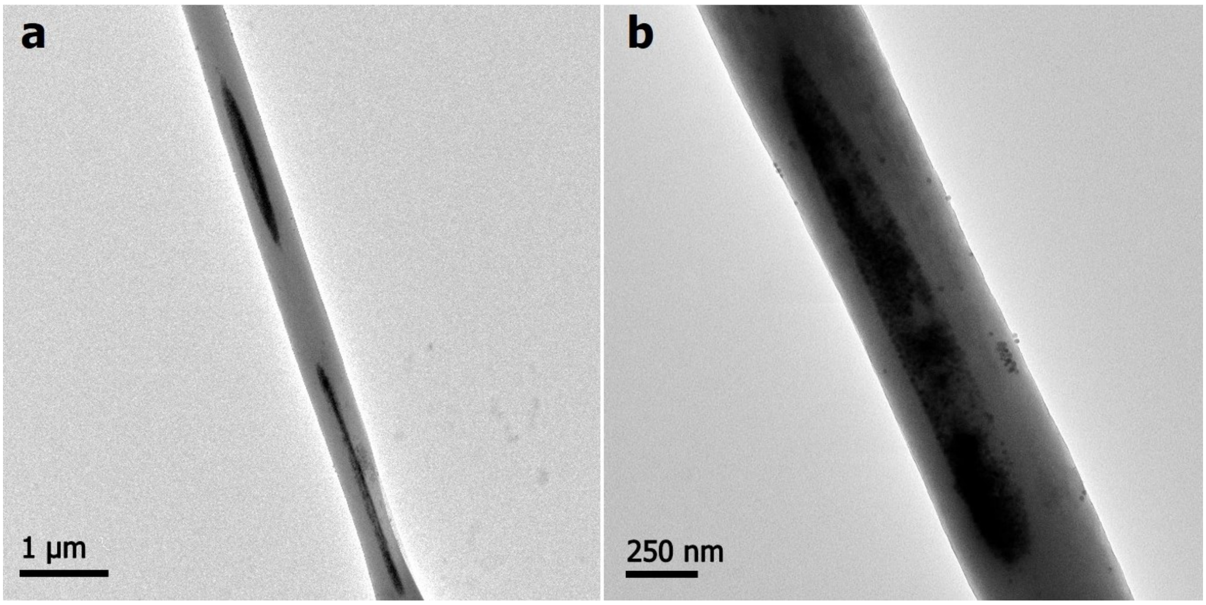

Figure S1. TEM images of the 12 nm-Fe_3O_4/PAN nanofibers electrospun with CTAB additive. a) Low-resolution image, and b) High-resolution image.

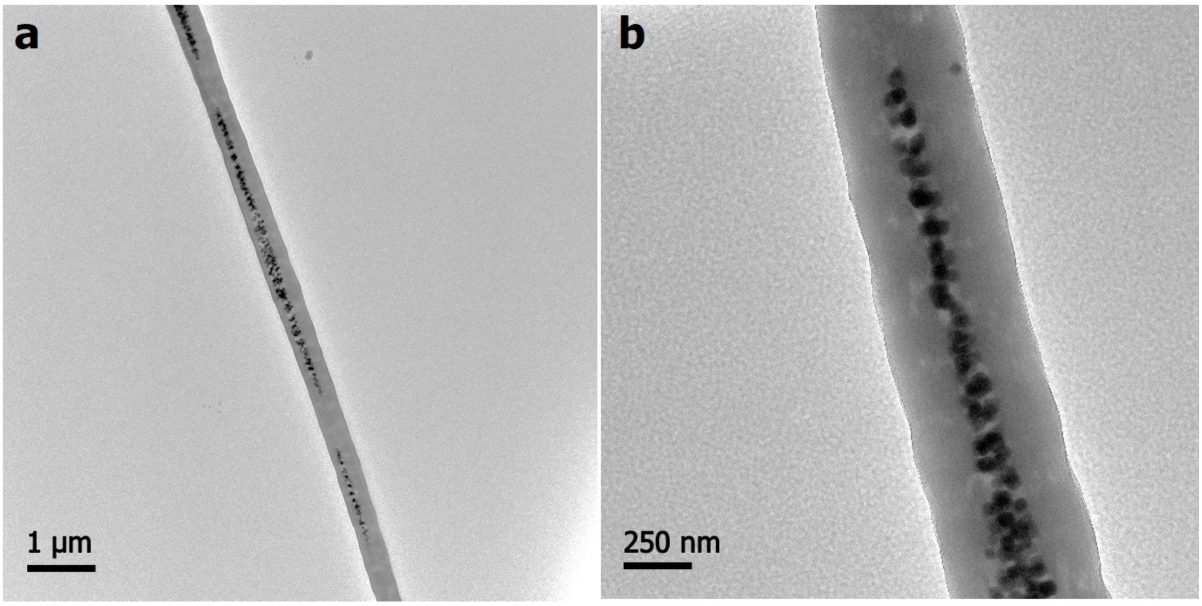

Figure S2. TEM images of the 45 nm-Fe_3O_4/PAN nanofibers a) Low-resolution image, and b) High-resolution image.

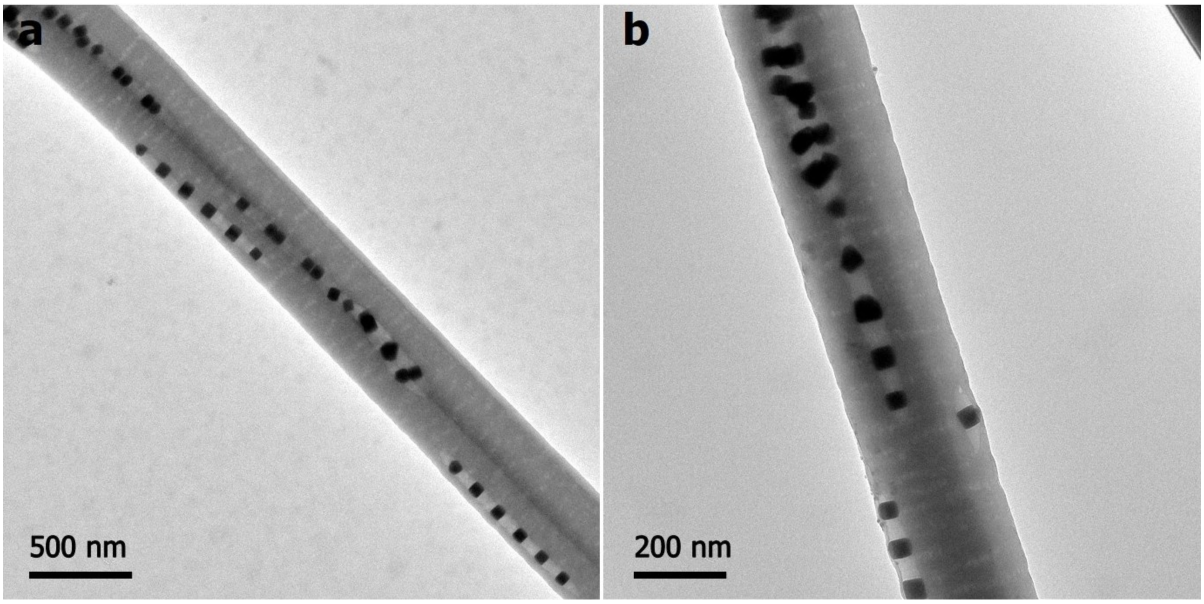

Figure S3. TEM images of the 80 nm-Fe_3O_4/PAN nanofibers a) Low-resolution image, and b) High-resolution image.

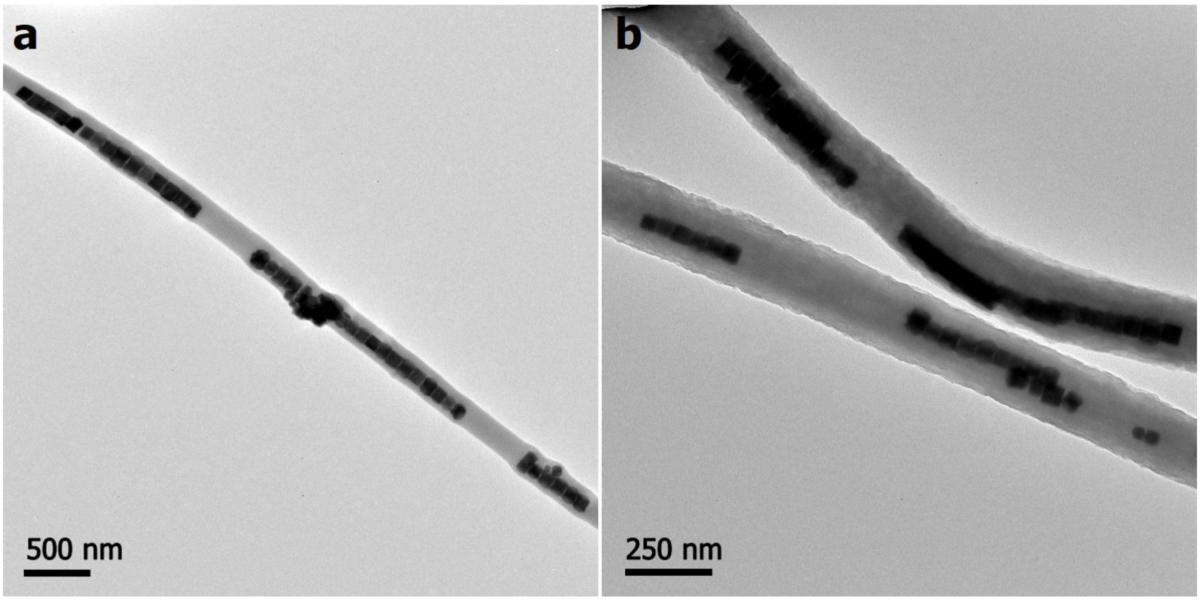

Figure S4. TEM images of the 110 nm-Fe_3O_4/PAN nanofibers. a) Low-resolution image, and b) High-resolution image.

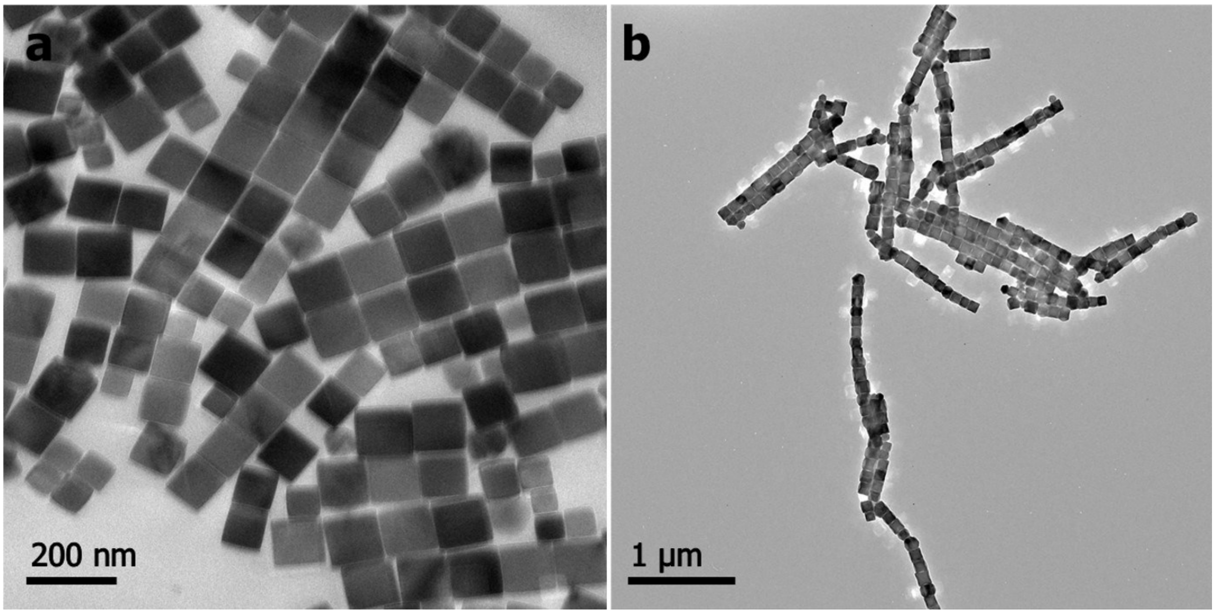

Figure S5. TEM images of the 110 nm Fe_3O_4 nanoparticles a) before, and b) after the DMF washed.

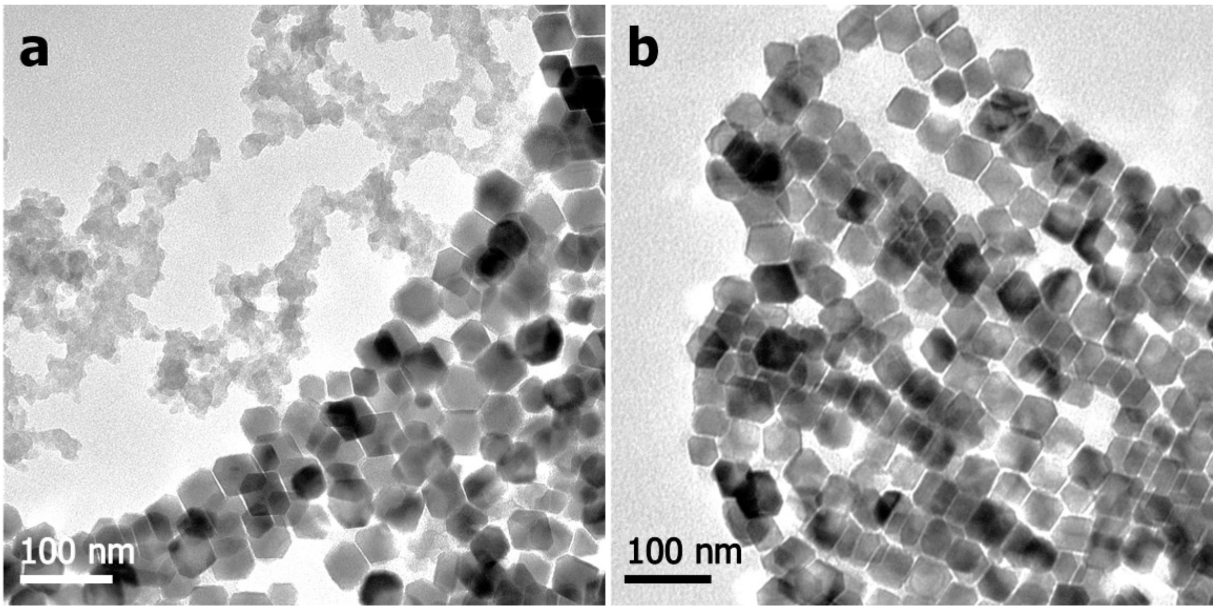

Figure S6. TEM images of the 45 nm Fe_3O_4 nanoparticles a) before, and b) after the DMF washed.

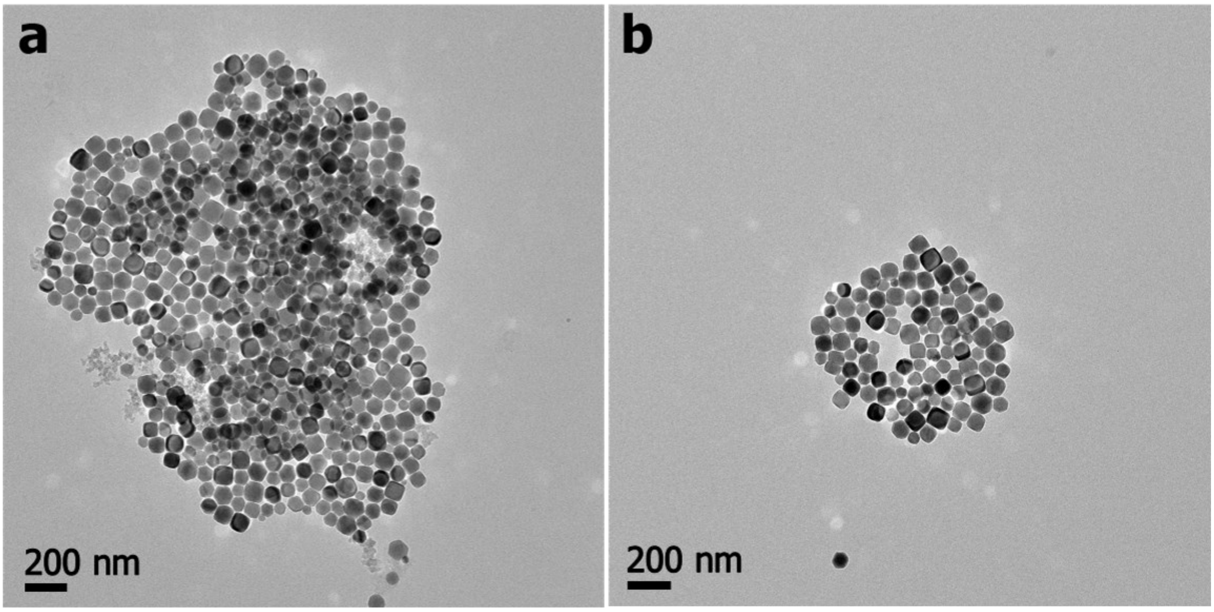

Figure S7. TEM images of the 80 nm Fe_3O_4 nanoparticles a) before, and b) after the DMF washed.

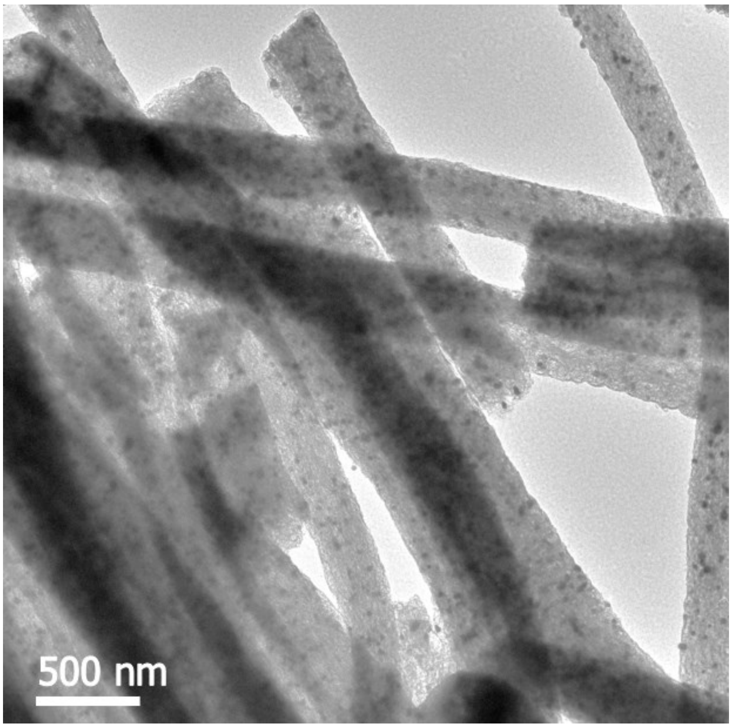

Figure S8. TEM images of the 12 nm Fe_3O_4 /carbon nanofibers.

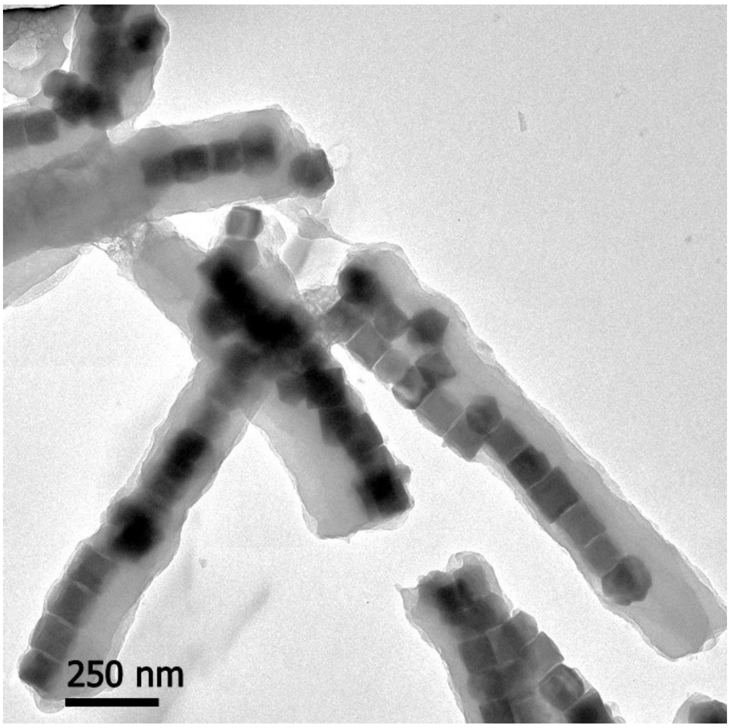

Figure S9. TEM image of the 110 nm-Fe_3O_4/PAN nano-stirbars after soaking in base solution with pH 12 for 24 h.

Video S1: Nano-stirbars stirring while blinking.

Video S2: Dispersion of dye in the water droplet with nano-stirbars stirring.

Video S3: Continuous production of nano-stirbars via electrospinning.