Supplementary Information for

Hybrid gas-phase synthesis of nanoscale Fe-SiO_2 core-shell agglomerates for efficient transfection into cell and use in magnetic cell patterning

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EXPERIMENTAL DETAILS

Hybrid gas-phase synthesis of nanoscale Fe-SiO_2 core-shell agglomerates: As shown in Fig. S1, a spark discharge was used to produce Fe nanoparticles in the gas-phase, and the particle-laden flow was employed as the operating gas for atomizing the SiO_2-PEI (408700, Sigma-Aldrich, US) solution. Spark discharge has been used to produce a variety of metallic, carbonaceous, and other composite materials with nanoscale dimensions at ambient temperatures and pressures. For the preparation of the nanoscale SiO_2 spheres, Solution 1 was a tetraethoxysilane (Merck, US), and Solution 2 was a mixture solution of 4.8 mL ammonia (25%), 63 mL ethanol (EtOH), and 20 mL deionized water. Solutions 1 and 2 were injected drop by drop with the aid of a peristaltic pump (323Du/MC4, Watson-Marlow Bredel Pump, US) at constant rates of 0.4 and 3.1 mL min^{-1}, respectively. Solutions 1 and 2 were mixed in a flask and an ultrasonic probe (VCX 750, 13 mm titanium alloy horn, 20 kHz, Sonics & Materials Inc., US) was then immersed into the mixture solution. The probe acted as an ultrasound irradiator (10 W mL^{-1} input power density) and the active part of the probe was the planar circular surface, of area 1.3 cm^2, at the bottom of the probe. The Fe particles passed over the atomizer orifice, where they mixed with atomized SiO_2-PEI droplets to form hybrid droplets. The droplets then passed through a heated tubular chamber to extract solvent from the droplets to form nanoscale Fe-SiO_2 core-shell agglomerates.

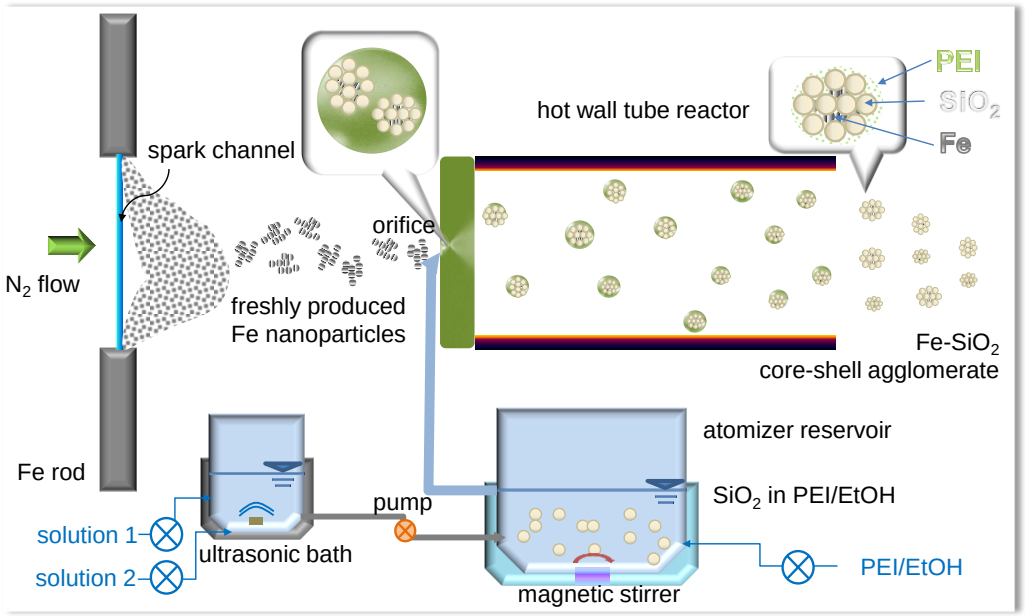

Fig. S1. Continuous hybrid gas-phase synthesis of nanoscale Fe-SiO_2 core-shell agglomerates. PEI was added during gas-phase synthesis to form simultaneously cationic layers on the surface of the Fe-SiO_2 agglomerates.

In vitro cell viability and gene transfection efficiency:

The cytotoxicity of the samples was evaluated using HeLa cells by the MTT, [3–(4,5–dimethylthiazol–2–yl)–diphenyltetrazolium bromide], assay. The cells were cultured in 200 mL Dulbecco's modified eagle medium (DMEM, Carlsbad, US) supplemented with 10% fetal bovine serum (FBS) at 37°C, 5% carbon dioxide, and 95% relative humidity. The cells were seeded in a 96-well microtiter plate (Nunc, Germany) at densities of 1×10^5 cells $well^{-1}$. After 24 h, the culture media were replaced with serum-supplemented culture media containing the sample, and the cells were incubated for 24 h. 30 µL of the MTT reagent was then added to each well. The cells were incubated for an additional 2 h. The absorbance was then measured using a microplate reader (Spectra Plus, TECAN, Switzerland) at a wavelength of 490 nm. The cell viability (%) was compared with that of the untreated control cell in media without sample and calculated using $[A]_{test}$:$[A]_{control} \times 100\%$, where $[A]_{test}$ is the absorbance of the wells with sample and $[A]_{control}$ is the absorbance of the control wells.

HeLa cells were seeded in 24-well plates at a density of 1×10^6 cells $well^{-1}$ in 1 mL of complete DMEM medium supplement with 10% FBS at 37°C, 5% carbon dioxide, and 95% relative humidity, one night before transfection. The culture medium was replaced with serum free DMEM medium, and transfection complexes were added to the cells. The cells were incubated with the transfection complexes at 37°C for an additional 24 h after the medium was replaced by fresh complete medium. After incubation for 24 h, the medium was aspirated and washed with phosphate-buffered saline. The cells were trypsinized and the transfection results were then measured with a luminometer (TD-20/20, Promega, US). The final luciferase activity was expressed in relative light units (RLU) mg^{-1} of protein.

The aerosolized samples were detached from the polytetrafluoroethylene substrate by immersing the substrates in water and subjecting them to ultrasound treatment for 10 s. Measurements of cell viability and transfection efficiency were performed in triplicate at least, with the average values with their deviation reported.

SUMMARY OF PARTICLE SIZE DISTRIBUTION

Table S1 A summary of the size distributions of spark produced Fe, collison atomized SiO_2, and their incorporated structure (Fe-SiO_2) from hybrid gas-phase route

Case	GMD (nm)	GSD (-)	TNC ($\times 10^6$ particles cm^{-3})
Fe	25.7	1.46	3.18
SiO_2	113.5	1.77	1.88
Fe-SiO_2	96.7	2.09	2.12

STRUCTURAL CHARACTERIZATION

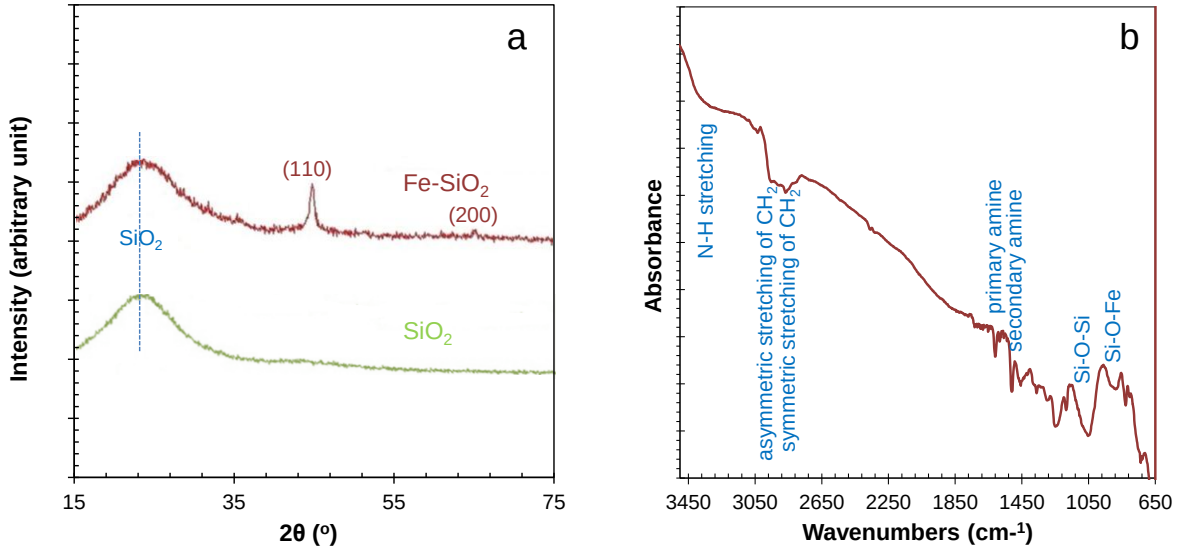

Figure S2. (a) XRD patterns of Fe and Fe-SiO_2 samples. (b) FTIR spectrum of the Fe-SiO_2 sample.

MAGNETIC PROPERTY

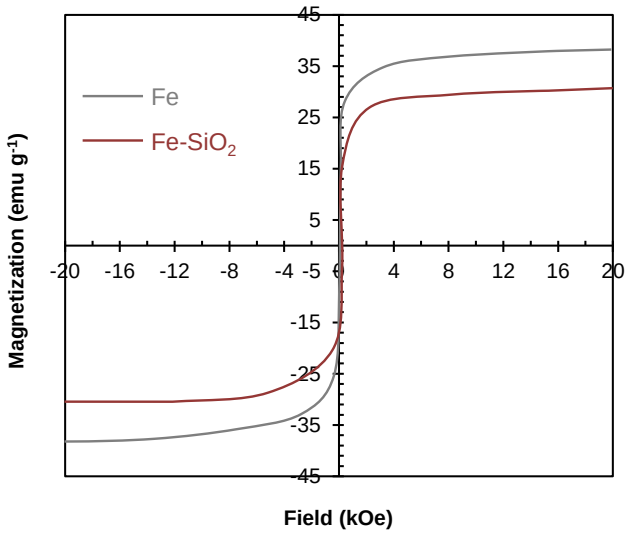

Figure S3. Magnetic properties of Fe and Fe-SiO_2 samples.

gfp EXPRESSION

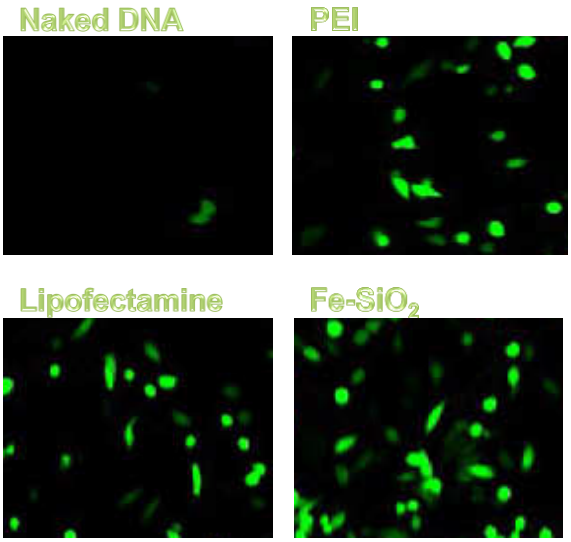

Figure S4. Transfection fluorescence imaging of naked DNA, PEI, lipofectamine, and Fe-SiO_2 samples in HeLa cells for 24 h.