Electronic Supplementary Material (ESI) for Physical Chemistry Chemical Physics.
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Supporting Information

Ultrasmall $SnFe_2O_4$ nanoparticles anchored on N-doped carbon nanofibers for ultralight and high-performance microwave absorption

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Experimental details

Preparation of N-CNFs

N-CNFs were prepared by facile electrospinning technique, which is schematically illustrated in former part of Fig 1a. Briefly, 2.0 g of PAN (polyacrylonitrile) was dissolved in18g of DMF (N-N dimethyl formamide) by magnetically stirring until the solution was totally transparent at room temperature. The obtained solution was transferred to a 20 mL syringe equipped with a stainless needle on TL-01 electrospinning machine with an operating voltage of 15 kV, spinning distance of 15 cm, and propulsion speeding rate of 0.5 mL/h for electrospinning. Afterward, the collected precursor fibers after drying overnight at 80 °C were pre-oxidized at 250 °C for 1 h and carbonized at 800 °C for 3 h under nitrogen atmosphere to yield N-CNFs. Finally, the obtained N-CNFs were immersed in concentrated nitric acid solution for 12h to activate their surface functional groups, and then were washed and dried by deionized water and alcohol to obtain the standby N-CNFs.

Preparation of SFO/N-CNFs

The SFO/N-CNFs were prepared by electrospun combined with a solvothermal method, whose fabrication process is illustrated in Fig. 1a. Typically, the stoichiometrical $SnCl_2 \cdot 2H_2O$, $FeCl_3 \cdot 6H_2O$ (1:2 in molar ratio) were firstly added into 50 mL glycol solution with magnetic stirring to fully dissolve the metal salt, and then 0.15g NaOH was added in the solution. Then, 10 mL of ammonia water was dropwise added and the above solution was heated in water bath at 50 °C for 1 h. Afterward, a certain amount of N-CNFs was added and stirred magnetically for 3 h to make the N-CNFs evenly dispersed in the precursor solution. Finally, the solution was poured in a Teflon liner hydrothermal reactor and heated at 200 °C for 15 h. After that, the collected sample was washed several times with distilled water. Then the brown powder was dried at 80 °C to obtain SFO/N-CNFs. For comparison, the pure N-CNFs was prepared using the same method.

Characterization

The crystal structure and phase composition of the composites were identified using X-ray diffraction (XRD, Rigaku D/max-2500PC) with Cu Kα (λ=0.15406 nm) radiation in the 2θ angle range of 20°–70°. The surface morphology and elemental composition were characterized by field-emission scanning electron microscope (FE-SEM, JEOL JSM-7001F). The microstructure was observed via high-resolution transmission electron microscopy (HR-TEM, JEOL JEM-2100) operated at 200 kV. Surface chemical compositions and valence states were determined through X-ray photoelectron spectroscopy (XPS). The spectra were collected on a Thermo Scientific K-Alpha+ XPS system equipped with a monochromatic Al Kα X-ray source, and the binding energies were calibrated using the C1s peak at 284.8 eV. Thermogravimetry (TG) analysis was conducted on a Shimzdu DTG-60 thermal analyzer in air atmosphere from 25 to 800 °C at a ramping rate of 10 °C min^{-1}. EM parameters of the SFO/CNFs-silicone rubber composite and the pure CNFs-silicone rubber composite were measured on a vector network analyzer (VNA, Agilent N5224A) using the reflection/transmission coaxial line method in the 2–18 GHz frequency range. The composites for EM measurements were prepared through uniformly mixing the silicone rubber and SFO/N-CNFs with a filling ratio of 5 wt%, and then pressed into toroidal-shaped specimens (Φ_{in} = 3.04 mm and Φ_{out} = 7.00 mm).

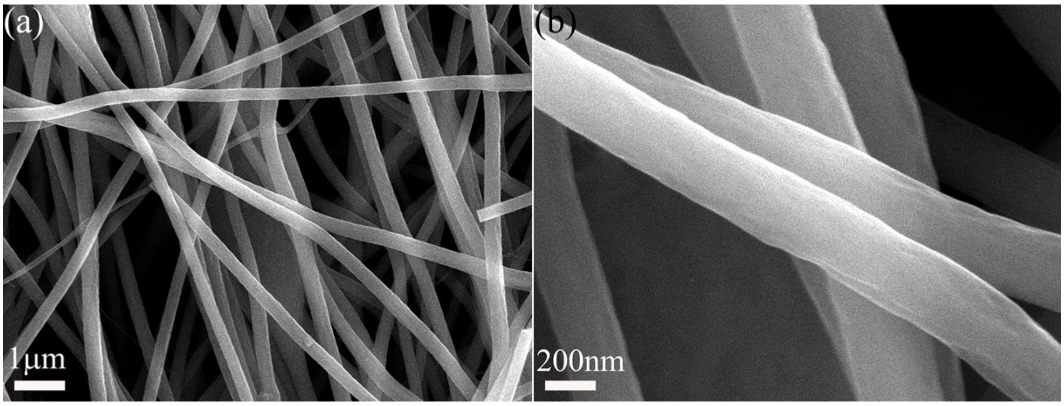

Fig. S1. SEM image of N-CNFs.

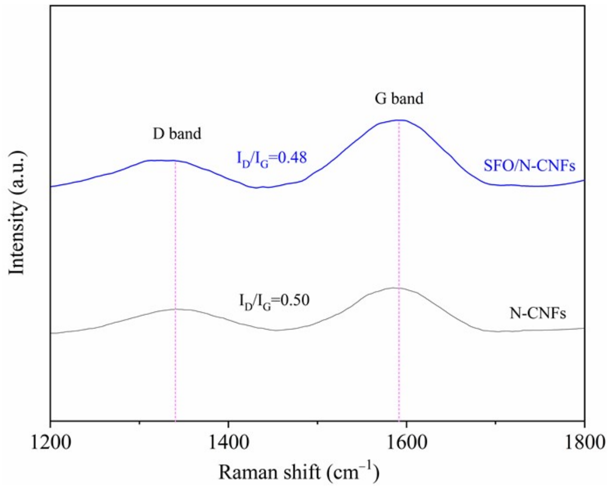

Fig. S2. Raman spectra of N-CNFs and SFO/N-CNFs.

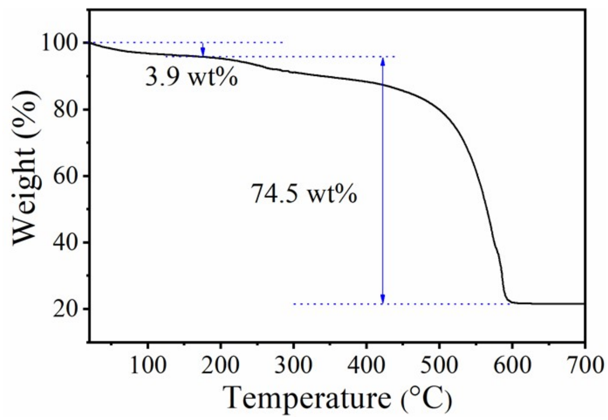

Fig. S3. TG curve of SFO/N-CNFs.

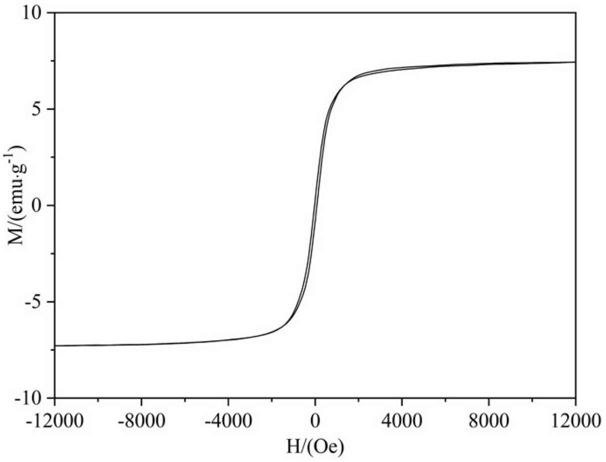

Fig. S4. Room-temperature hysteresis loop of SFO/N-CNFs.

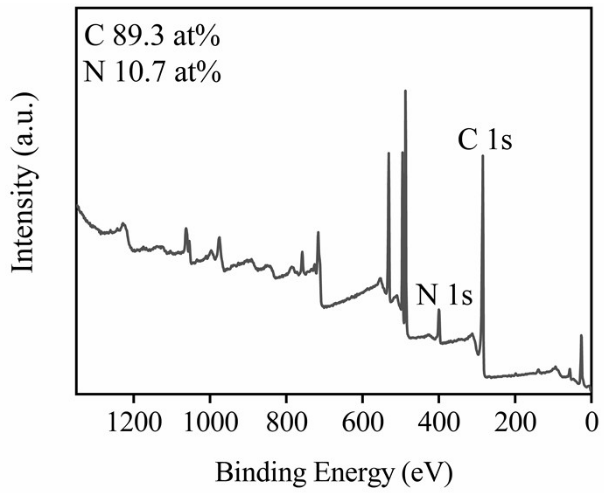

Fig. S5. XPS survey spectrum of SFO/N-CNFs.

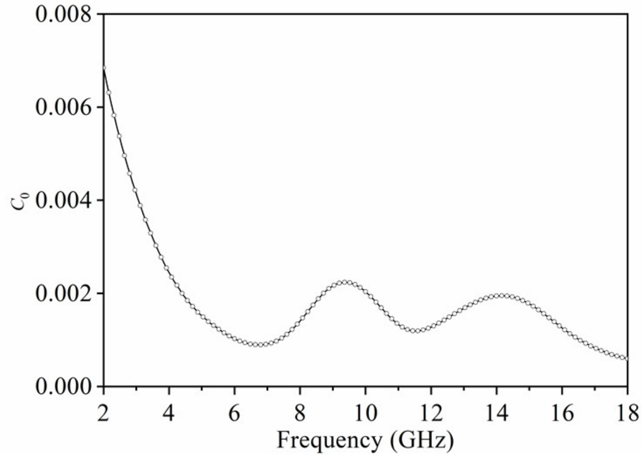

Fig. S6. Frequency dependence of C_0 value for SFO/N-CNFs.

Table S1. Comparison of microwave absorption properties of SFO/N-CNFs and some previously reported ferrite/carbon composite absorbers.

Sample	Filler loading (wt%)	RL_{min} (dB)	Matching thickness (mm)	Max bandwidth (EAB_{10})	Ref.
CCFs-Fe_3O_4	30	–56.8	1.67	1.6 (10.2–11.8)	[8]
MWCNTs/$ZnFe_2O_4$	50	–55.5	1.5	3.6 (12–15.6)	[22]
$MnFe_2O_4$@C	50	–48.9	2.5	1.4 (0.38–1.78)	[23]
$NiFe_2O_4$-Graphene	60	–29.2	2.0	4.4 (13.6–18.0)	[24]
$CoFe_2O_4$/CNFs	20	–14.0	2.5	3.6 (12 –15.6)	[25]
CNTs/$NiCo_2O_4$	30	–45.1	2.5	2.7 (7.8–10.5)	[26]
$ZnCo_2O_4$/C/MG	50	–52.9	3.9	4.5 (5.1–9.6)	[27]
$ZnFe_2O_4$@C/MWCNTs	50	–40.7	2.5	0.9 (0.5–1.4)	[28]
C@$NiCo_2O_4$@Fe_3O_4	60	–43.0	3.4	2.1 (12.8–14.9)	[29]
SFO/N-CNFs	5	–46.5	2.1	4.8 (12.7–17.5)	This work