Supporting Information

Nanocellulose Assisted Preparation of Ambient Dried, Large-Scale and Mechanically Robust Carbon Nanotube Foams for Electromagnetic Interference Shielding

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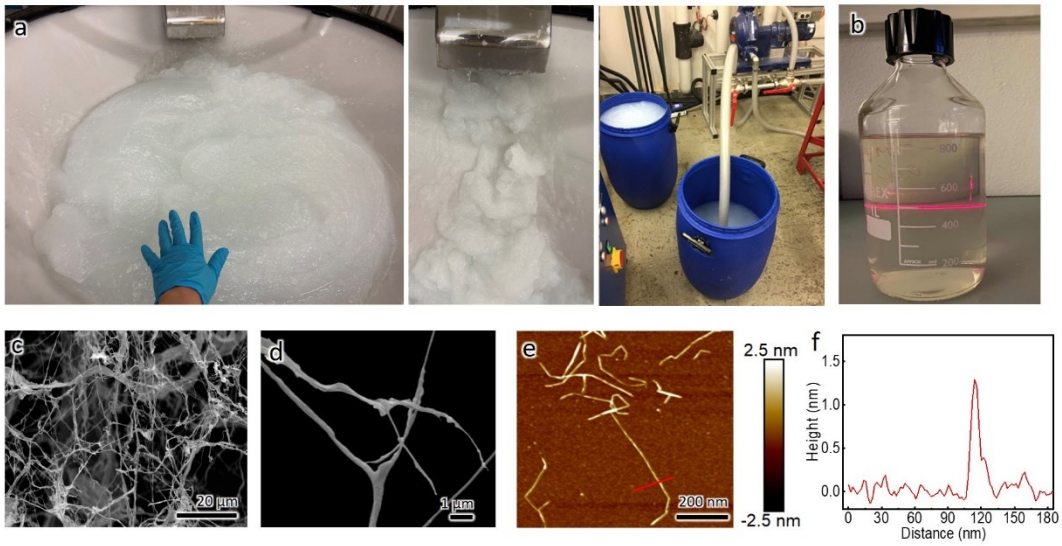

Fig. S1. Properties of large scale produced NFC. (a) Optical images of the mass-produced NFCs dispersion during the grinding process. (b) Typical Tyndall effect upon a laser pass through the dispersions. (c, d) SEM images of the NFCs. (e) AFM image of the NFCs and (f) corresponding height profile of the line in image e, showing the ultrathin dimension and large aspect ratio of NFCs.

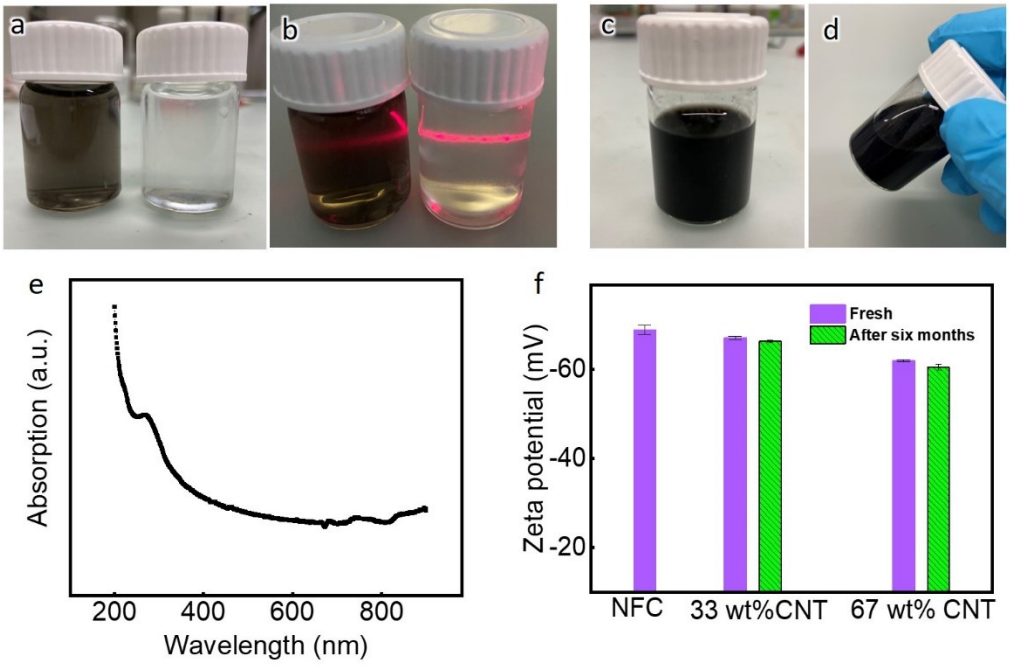

Fig. S2. Properties of the CNT dispersions. Optical images of (a) CNT/33 wt% NFC (left) and NFC (right) dispersions and (b) the Tyndall effect upon a laser pass through the dispersions. Optical images of CNT/33 wt% NFC dispersion (c) before and (d) after storing for six months. (e) Typical UV−vis spectrum of the as-prepared CNT dispersion. (f) Zeta potential of the CNT based dispersions with various NFC contents before and after storing for six months.

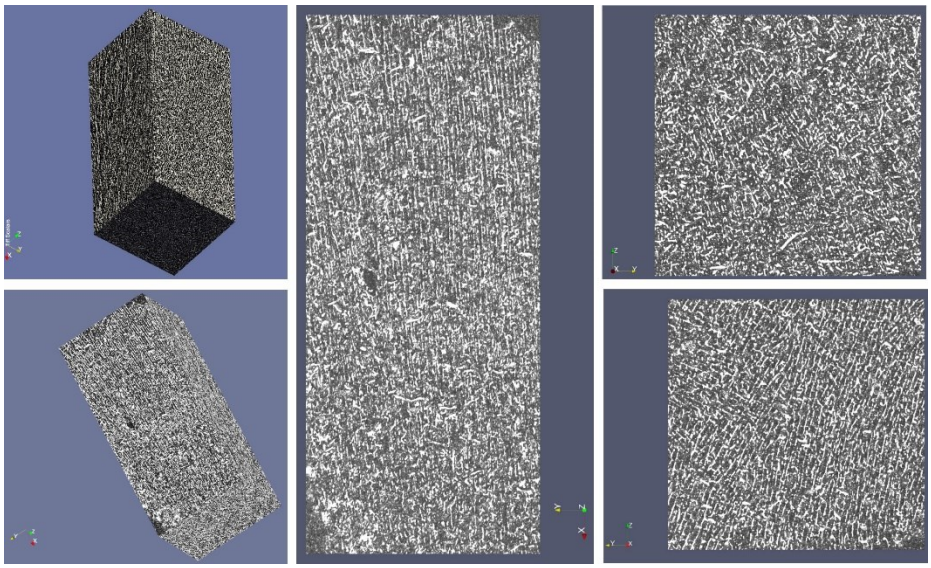

Fig. S3. X-ray tomography of the air-dried CNT foams and corresponding 2D projection images in the 3D structure, many of which were used to reconstruct the 3D networks.

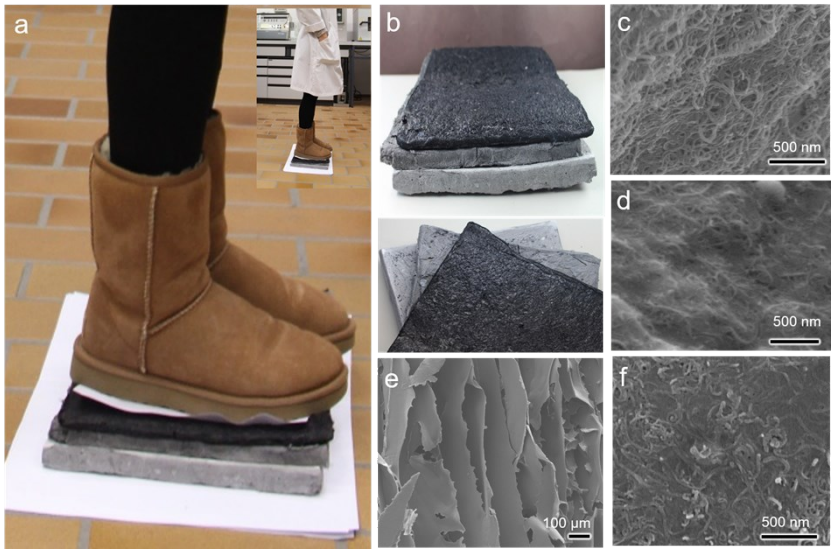

Fig. S4. (a, b) Optical images of large-area air-dried CNT based foams (with 33 wt% NFC, 75 wt%, and 95 wt% NFC) that sustain a person weighing 45 kg at a density of around 20 mg/cm^3. SEM images of the air-dried CNT foams with (c) 33 wt% NFC, (d) 50 wt% NFC, and (e, f) 75 wt% NFC at a similar density of 18 mg/cm^3.

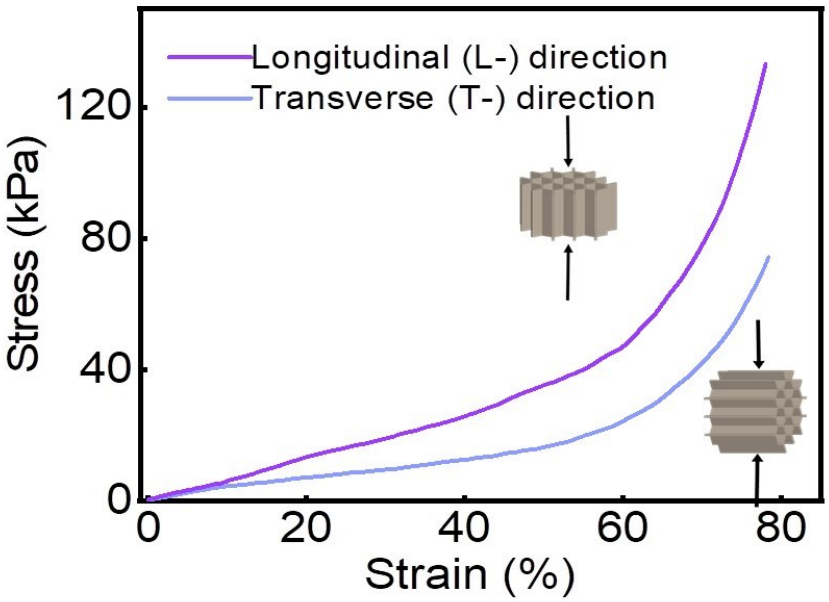

Fig. S5. Longitudinal and transverse compressive curves of the air-dried CNT foams (33 wt% NFC, density of 18 mg/cm^3).

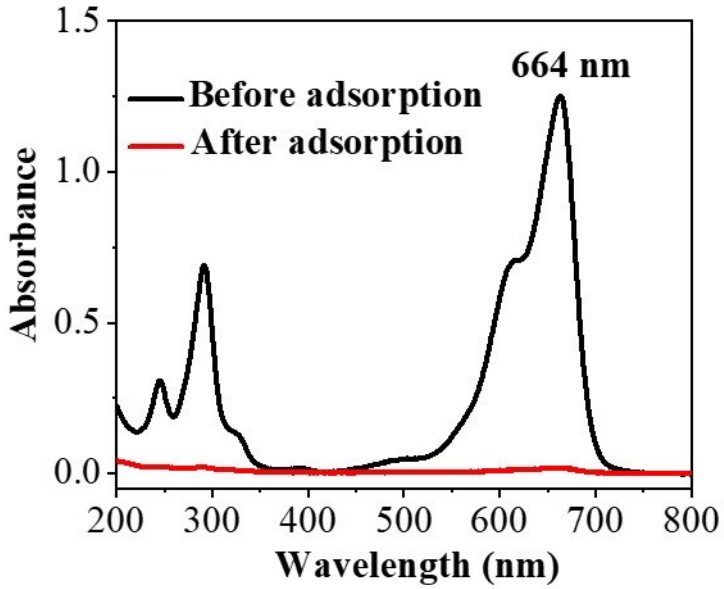

Fig. S6. UV curves of the MB solution before and after adsorption by the air-dried CNT based foams.

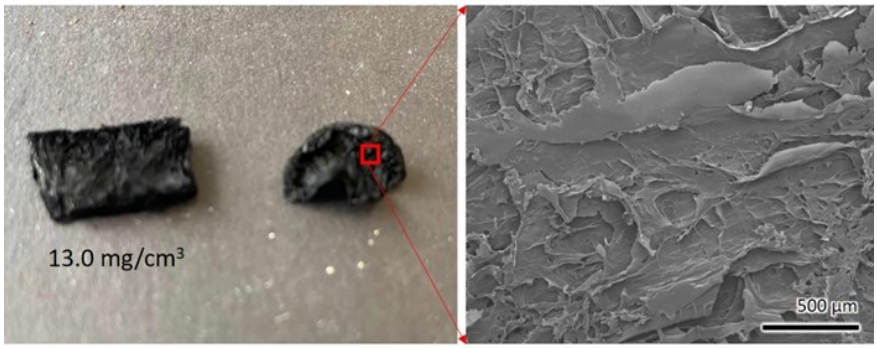

Fig. S7. Optical and SEM images of the air-dried CNT foam with 13 mg/cm^3 (left) and the sample prepared from a too low concentration of precursor dispersion (for preparing the foams with a density of 8 mg/cm^3) such that it shows significant volume shrinkage upon drying.

Table S1. Relationship among EMI SE, attenuation, and transmission efficiency (T).

EMI SE (dB)	Attenuation (%)	T (%)
10	90	10
20	99	1
30	99.9	0.1
40	99.99	0.01
50	99.999	0.001
60	99.9999	0.0001
70	99.99999	0.00001
80	99.999999	0.000001

Table S2. Properties of the air-dried CNT foams (density of 18 mg/cm^3) at various NFC contents.

NFC content (wt %)	CNT content (wt%)	CNT volume content (vol%)	Conductivity (S/m)
33	67	0.70	5.1
50	50	0.49	1.7
67	33	0.30	0.7
75	25	0.22	/
100	0	0	/

Table S3. Properties of the air-dried CNT foams (33 wt% NFC) at various densities.

Density (mg/cm^3)	Porosity	CNT volume content (vol%)	Weight reduction (%)	Conductivity (S/m)
63	0.958	2.59	95.8	9.5
28	0.981	1.08	98.1	6.4
18	0.988	0.70	98.8	5.1
13	0.991	0.50	99.1	3.4

Table S4. EMI shielding performance of some typical shielding materials.

Materials	EMI SE (dB)	Density (mg/cm^3)	Thickness (mm)	Density normalized specific SE (dB·cm^3/g)	SSE (dB·cm^2/g)
Carbon-based porous and solid shields					
CNF/PS foam[1]	19		/	/	/
CNT/PS foam[2]	19	574	/	33.1	/
Graphene/PVDF foam[3]	28		/	/	/
Graphene/PMMA foam[4]	19	792	2.4	24	100
Graphene/PS foam[5]	29	450	2.5	64.4	258
Graphene /PEI foam[6]	9-12.8	~290	2.3	31– 44	135–192
Graphene@Fe_3O_4/PEI foam[7]	15-18	400	2.5	37.5–44	150–176
CF/PP foam[8]	25	735	3.1	34	109
Stainless-steel fiber/PP foam[9]	48	640	3.1	75	242
MWCNT/PLA foam[10]	23	299	2.5	77	308
MWCNT/PVDF foam[11]	57	750	2	76	380
MWCNT/WPU foam[12]	23.0	20	2.3	1148	4991
	21.1	39	1	541	5410
MWCNT/cellulose aerogel[13]	20-35	~37-47	2.5	425-944	1700-3776
Cellulose aerogel coated with MWCNT[13]	35-40	~69-75	2.5	466-519	1864-2078
Graphene foam based PDMS foam[14]	30	60	1	~500	~5000
Graphene foam/CNT/PDMS[15]	75	90	2	833	4165

Graphene-coated PU foam[16]	19.9	30.0	20	663.3	3320
Graphene foam coated with PEDOT:PSS[17]	69.1	22.1	1.5	3124	20837
Graphene based composite aerogel[18]	37	70	3	529	1762
Sponged-supported RGO aeroge[19]	24	16.7	12	1437	1198
CNT/multi-layered graphene foam[20]	~38	5.8	1.6	6600	~40000
Graphene aerogel[21]	22.3	4.5	2	4956	24778
Carbon foam-CNT/carbon fiber foam[22]	21	12.4	5.0	1690	3370
CNF mat[23]	81.1	219	4.6	370	804.3
	52.2	134	2.9	390	1361.6
Carbon/Graphene foam[24]	24	721	0.024	33.3	13889
Phthalonitrile-based carbon foam[25]	51.2	150	2	341.1	1707
Commercial carbon foam[26]	40	166	2	241	1250
CNT sponge[27]	22	20	2.38	1100	4622
MWCNT/PTT[28]	22	/	2		/
MWCNT/PP[29]	24	899	2.8	~26.7	95
	35	/	1.0	/	/
CNF sponge/Epoxy[30]	40	/	2	/	/
MWCNT/ABS[31]	50	1050	1.1	~47.6	433
Carbon black (CB)/ABS[31]	22	/	1.1	~20.9	~190
Carbon nanofiber (CNF)/ABS[31]	35	/	1.1	/	/
MWCNT/PC[32]	25	1200	1.85	/	112
MWCNT/PS[33]	60	/	2	~57	285
MWCNT/WPU[34]	24-50	1200	0.05-0.32	20-42	3408
SWCNT/epoxy[35]	25	1748	2	~14.3	72
SWCNT/PU[36]	18	/	2	~17	80
Graphene/WPU[37]	32		2	~30.5	153
CB/EPDM[38]	18	/	5.5	/	
Flexible Graphite[39]	110	1100	0.2	100	500
Metal-based porous and solid shields					
CuNi foam[40]	15-25	~240	1.5	63–104	420–690
CuNi-CNT foam[40]	40-54.6	~230	1.5	174–237	116–1580
Porous cellulose papers coated with Ag NWs[41]	48.6	530	0.164	91.7	5584
Ag NWs/PI foam[42]	17-23.5	22	5	1068-772	2136 -1544
Ag NWs/WPU foam[43]	20.0-64.0	8.0	2.3	2500-1422	10970-6184
Ag NW@C hybrid sponge [44]	37.9	3.8	1	9921	99214

Cu NWs aerogels[45]	~17		9.46	/	/
Cu NW@ graphene aerogels[45]	52.5	166	9.46	3170	3921.8
Copper[46]	90	8960	3.1	10	32
Nickel[46]	82	8900	/	9.2	
Stainless steel[46]	89	8100	4	11	28
(2 μm) Ni fibers/PES[46]	58	1871	2.85	31	109
(20 μm) Ni fibers/PES[46]	4	250	2.85	16	
Ni filaments/PES[45]	~87	/	2.85	47	165
Aluminium flakes/PES[47]	35-39	/	2.92	/	/
Ag NW/epoxy[48]	25.09	1255	0.040	20.0	5018
Ag NP/epoxy[48]	5.06	1234	0.040	4.1	1012
Ag NW/PVA[48]	30.1	1123	0.040	26.8	6691
Ag NW/PS[49]	31.85	1051	0.8	30.3	379
Cu NW/PS[50]	35	1051	0.21	33.3	158.7
MXene based cellular and solid shields					
MXene foam[51]	32	390	0.006	82	137000
MXene-POSS-NH2 aerogel[52]	34.5	/	2	/	/
MXene/PVA aerogel[53]	28	10.8	5	2586	5136
MXene/SA film[54]	57	~2317	0.008	24.6	30830
MXene/Nanocellulose film[55]	24	2000	0.047	12	2647
	25	1136	0.0167	22	1326
MXene@PS solids[56]	62	1051	2	59.0	29.5
MXene/RGO-epoxy solid[57]	56.4	/	2	/	/

/: unclear or uncalculated value; the numbers in the square brackets denote the numbers of references which are at the end of the supporting information.

Table S5. Properties of the air-dried CNT foam (33 wt% NFC) and corresponding compressed state (C-CNT).

Sample name	Density (mg/cm^3)	Thickness mm	Porosity	CNT volume content (vol%)	Conductivity (S/m)
CNT foam	18	2.0	0.988	0.70	5.1
C-CNT	450	0.08	0.700	17.4	420.8

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