Electronic Supplementary Information

Ultra-efficient highly-selective MFC-7 cancer cell therapy enabled by combined electric-pulse carbon 1D-nanomaterials platforms

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Supplementary Table S1 Dimensions of the electrothermal therapy model. Length of the cell layer and cell-CNT-cell layer was varied from 50 to 200 μm in 50 μm increments.

Material	Width (nm)	Length (μm)	Thickness (nm)
Silicon dioxide	3.5	101	0.5
Indium tin oxide	3.5	0.5	0.65
Carbon nanotubes	3.5	50 – 200	0.2
Cancer cells	3.5	50 – 200	0.22

Supplementary Table S2 Parameters used for the electrothermal therapy model.

Material	Isotropic thermal conductivity (W/mK)	Isotropic resistivity (Ωm)
Silicon dioxide	1.4	10^{14}
Indium tin oxide	4	1×10^{-6}
Carbon nanotubes	3000	5×10^{-7}
Cancer cells	0.63	0.9776

Supplementary Table S3 Significance for CNT cytotoxicity for MCF-10A cells and MCF-7 cells after (a) 24 h and (b) 48 h. Significance was measured using Student's t-test and is presented as: $p < 0.05$ (*), $p < 0.01$ (**), $p < 0.001$ (***) and $p < 0.0001$ (****). Unmarked significance denotes non-significance.

(a)

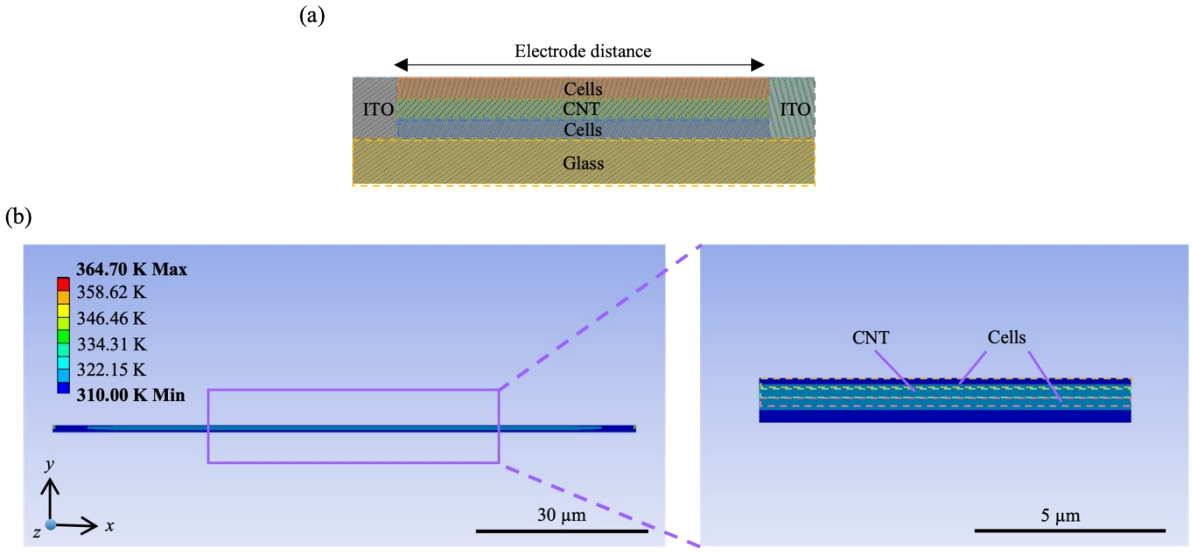
		Concentrations of CNT (µg/mL)			
		5	**10**	**20**	**30**
MCF-10A (*t* = 24 h)	Compared to Control				*
	Compared to 5 µg/mL				**
	Compared to 10 µg/mL				**
	Compared to 20 µg/mL				**
MCF-7 (*t* = 24 h)	Compared to Control		**	****	****
	Compared to 5 µg/mL			***	***
	Compared to 10 µg/mL			**	***
	Compared to 20 µg/mL				**

(b)

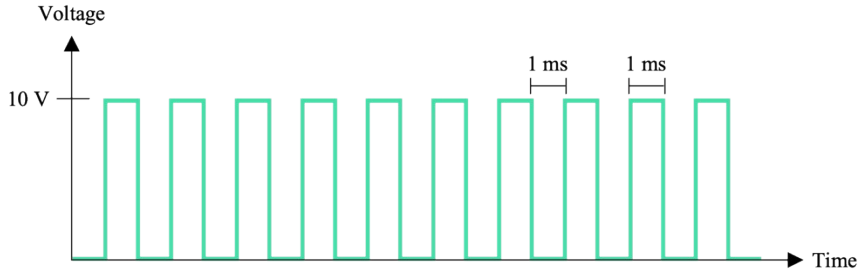
		Concentrations of CNT (µg/mL)			
		5	**10**	**20**	**30**
MCF-10A (*t* = 48 h)	Compared to *t* = 24 h			****	
	Compared to Control			**	***
	Compared to 5 µg/mL			**	***
	Compared to 10 µg/mL			**	**
	Compared to 20 µg/mL				
MCF-7 (*t* = 48 h)	Compared to *t* = 24 h	**	**	**	***
	Compared to Control	**	**	***	***
	Compared to 5 µg/mL			***	***
	Compared to 10 µg/mL			*	**
	Compared to 20 µg/mL				*

Supplementary Table S4 References for Fig. 3d. Percentage decrease in cell viability for state-of-the-art, carbon-based photothermal nanoagents without additional chemotherapeutic drugs.

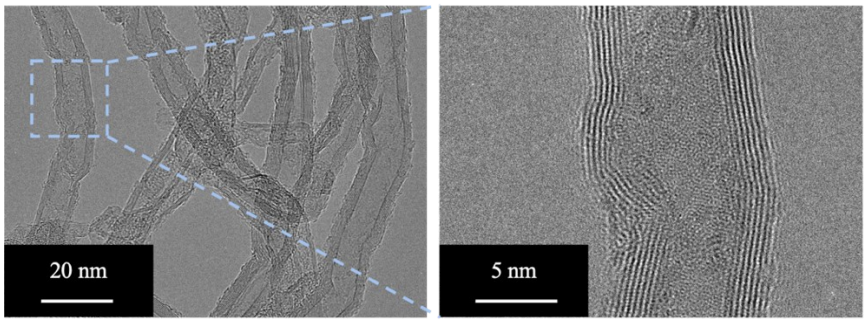
Ref no.	Reference
1	Wang, Y., Wang, H., Liu, D., Song, S., Wang, X., Zhang, H., Graphene oxide covalently grafted upconversion nanoparticles for combined NIR mediated imaging and photothermal/photodynamic cancer therapy. *Biomater.,* **34**, 7715-7724 (2013).
2	Liu, J., Wang, C., Wang, X., Wang, X., Cheng, L., Li, Y., Liu, Z., Mesoporous silica coated single-walled carbon nanotubes as a multifunctional light-responsive platform for cancer combination therapy. *Adv. Func. Mater.,* **23**, 384-392 (2014)
3	Sahu, A., Choi, W. I., Lee, J. H., Tae, G., Graphene oxide mediated delivery of methylene blue for combined photodynamic and photothermal therapy. *Biomater.,* **34**, 6239-6248 (2013)



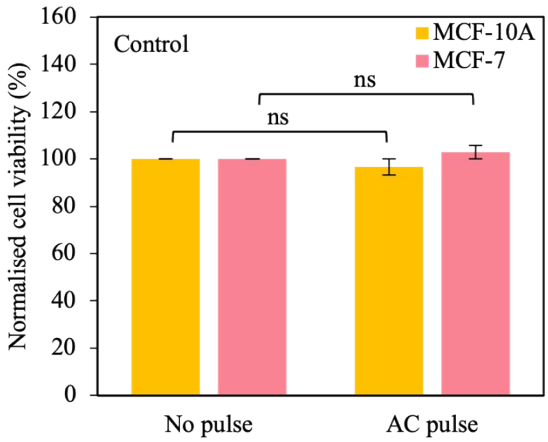
Supplementary Figure S1 Thermal modelling. (**a**) Model structure showing a cell-CNT-cell layer (model with CNT). The model comprised two indium tin oxide (ITO) electrodes on a glass substrate. The distance between the electrodes was varied from 50 – 200 µm in 50 µm increments. (**b**) Thermal distribution of the model with CNT with a 100 µm electrode gap. After applying a square bias-voltage pulse (10 V, pulse width = 1 ms), an increase in temperature was observed within the CNT layer and it propagated outwards to the cell layers. The image on the right presents a zoom-in snapshot of the center of the model.



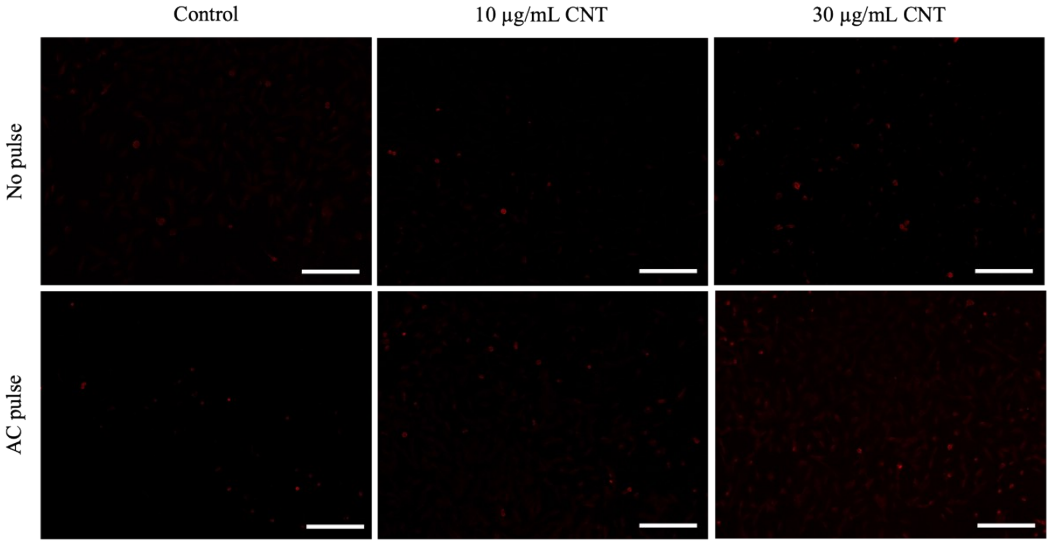
Supplementary Figure S2 Schematic illustration of the applied electrical waveform (AC pulses): 10 square bias-voltage pulses with an amplitude of 10 V and a pulse width of 1 ms.



Supplementary Figure S3 TEM images of tube-like features of CNT (left) with high magnified images of the CNT detailing defined carbon atoms lining the walls (right).



Supplementary Figure S4 Normalised cell viabilities for MCF-10A cells (yellow) and MCF-7 cells (pink) after applying the AC pulse. Values were normalised to cells without pulse. Data represent mean ± SEM, (n = 6 from 3 independent experiments). Significance was calculated using a Student's t-test. Non-significance is denoted as ns.



Supplementary Figure S5 Propidium iodide (PI) staining for MCF-10A cells ~24 h after AC pulse application. Cells were incubated with different CNT concentrations (0, 10 and 30 µg/mL). Scale bar is 200 µm.

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