Electronic Supplementary Material (ESI) for RSC Advances.

Supporting information

Comparison method effect on synthesize B, N, S, and P-doped carbon dots with high photoluminescence property on HeLa tumor cells

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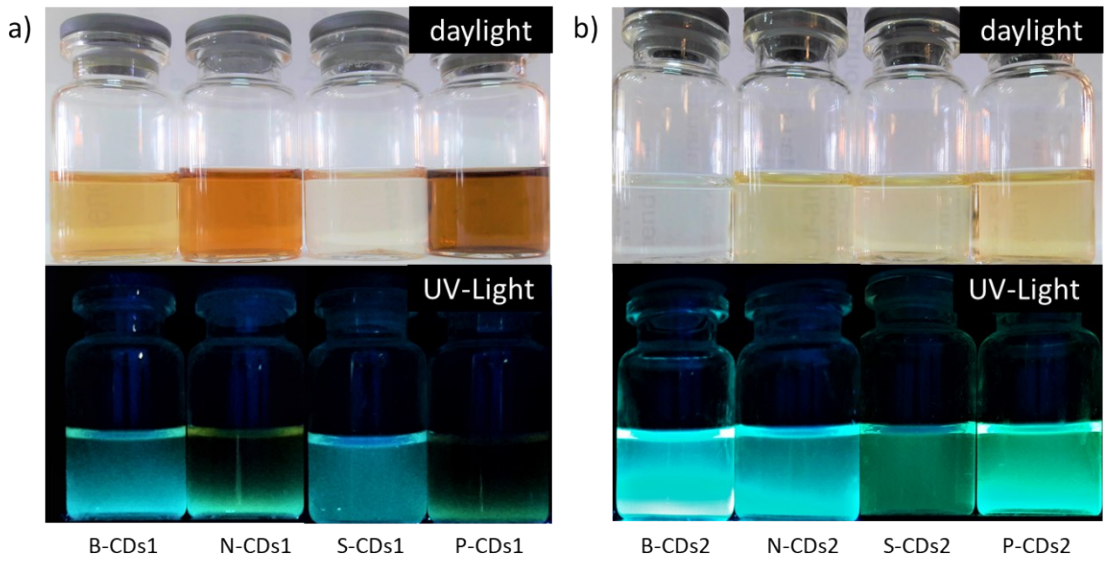

Fig S1 Photographs of doped CDs under daylight and UV-light prepared by Furnace assisted (a) and Microwave assisted (b) methods.

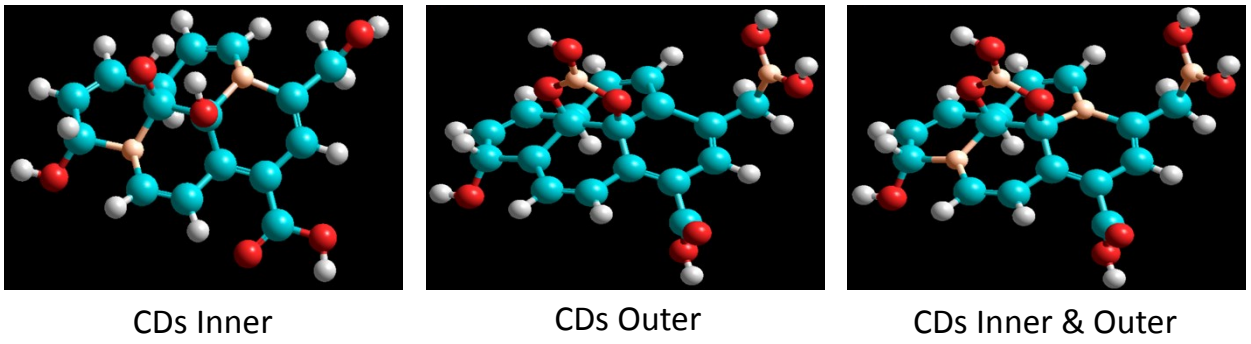

Fig. S2 Molecular structure of Pyrene doped with Boron, Nitrogen, Sulphur, and Phosphor on inner structure (CDs Inner), outer structure (CDs Outer), and its compilation (CDs Inner & outer). The white, red, cyan and orange ball represent of Hydrogen, Oxygen, Carbon and doping atom positions, respectively.

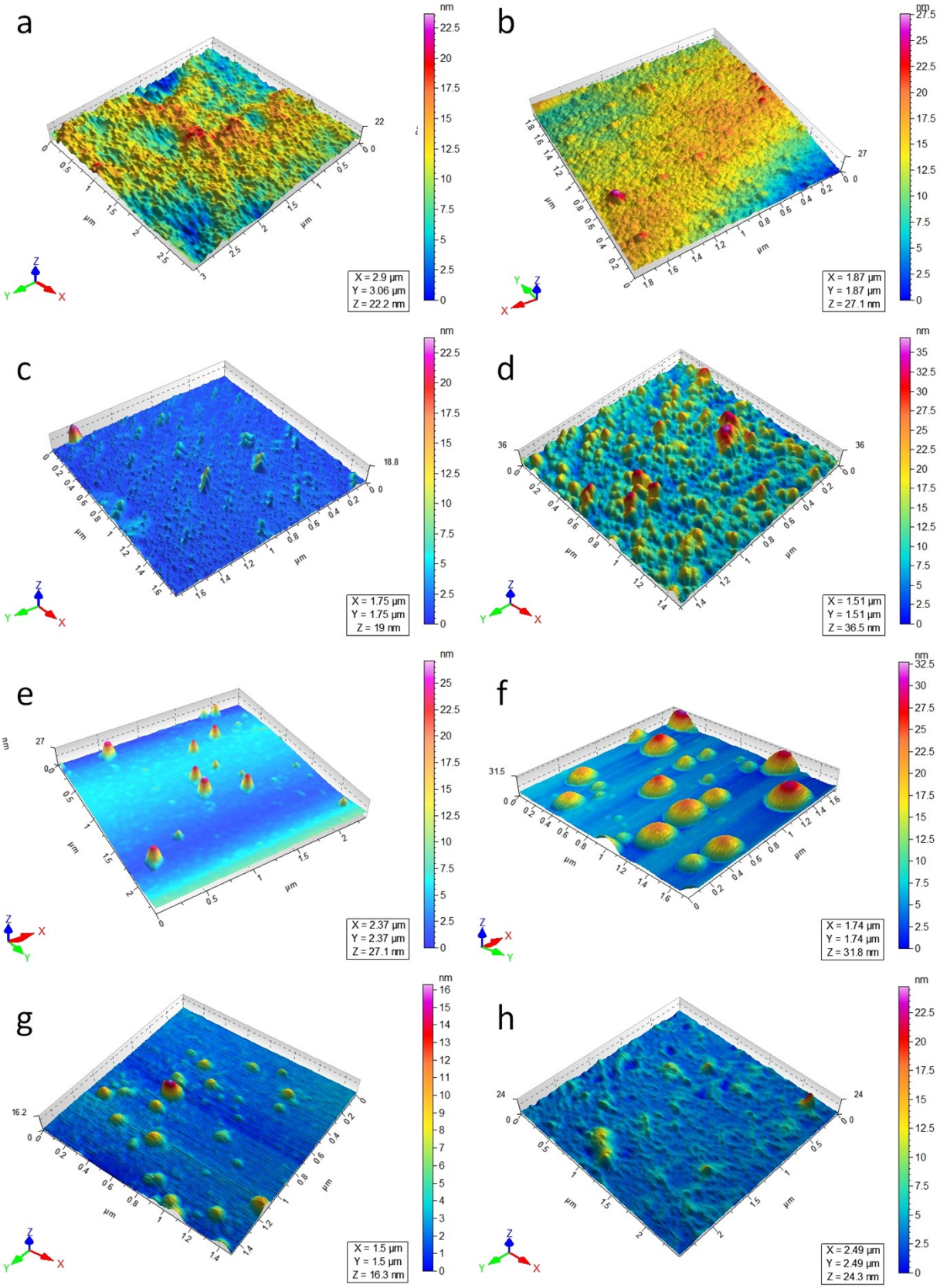

Fig. S3 AFM 3D topography images of **a** B-CDs1, **b** N-CDs1, **c** S-CDs1, **d** P-CDs1, **e** B-CDs2, **f** N-CDs2, **g** S-CDs2, and **h** P-CDs2.

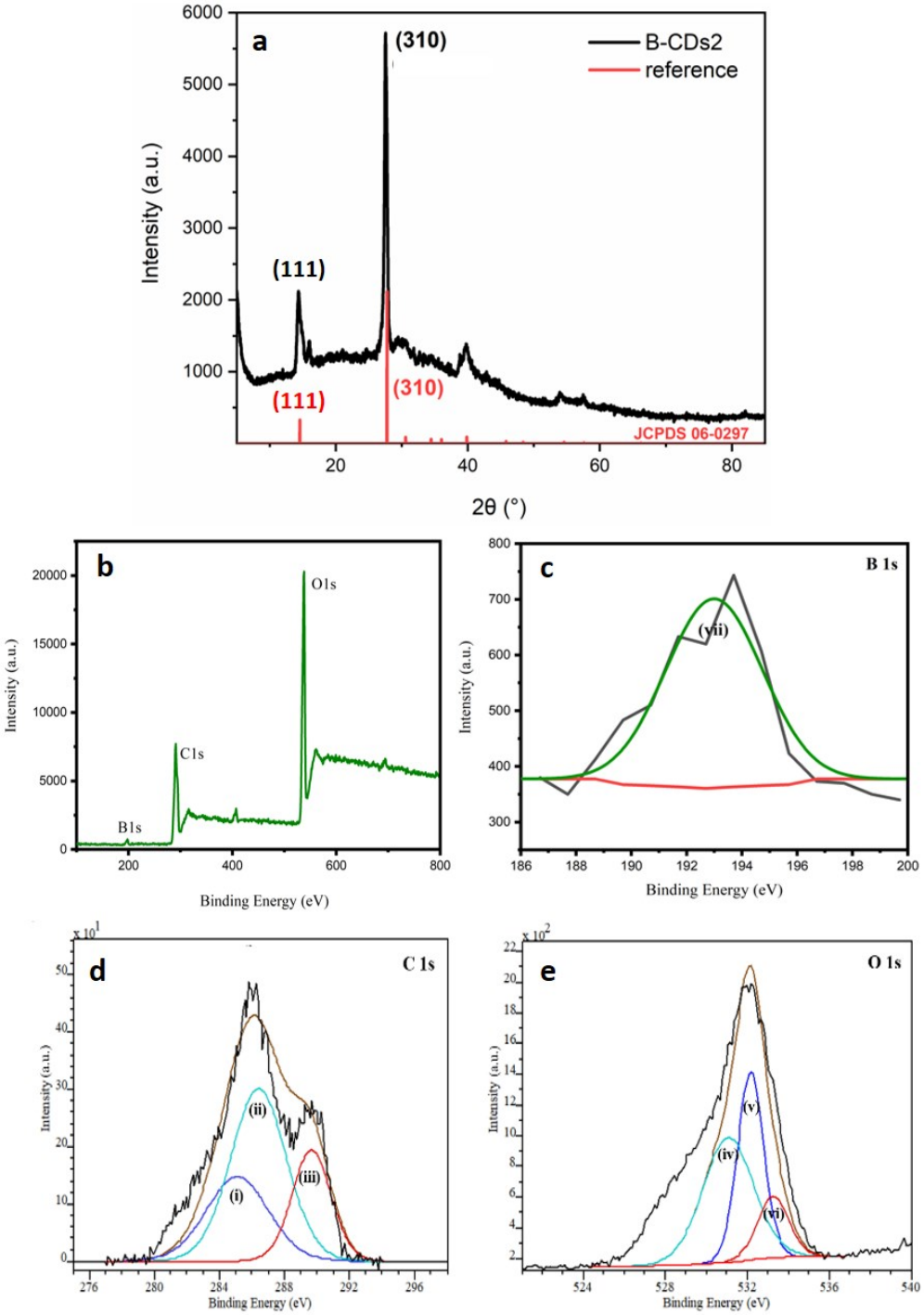

Fig. S4 a XRD diffractogram of B-CDs2 doped-carbon dots. B-CDs2 carbon dots XPS Spectra at **b** whole spectrum, **c** B 1s, **d** C 1s, and **e** O 1s regions.

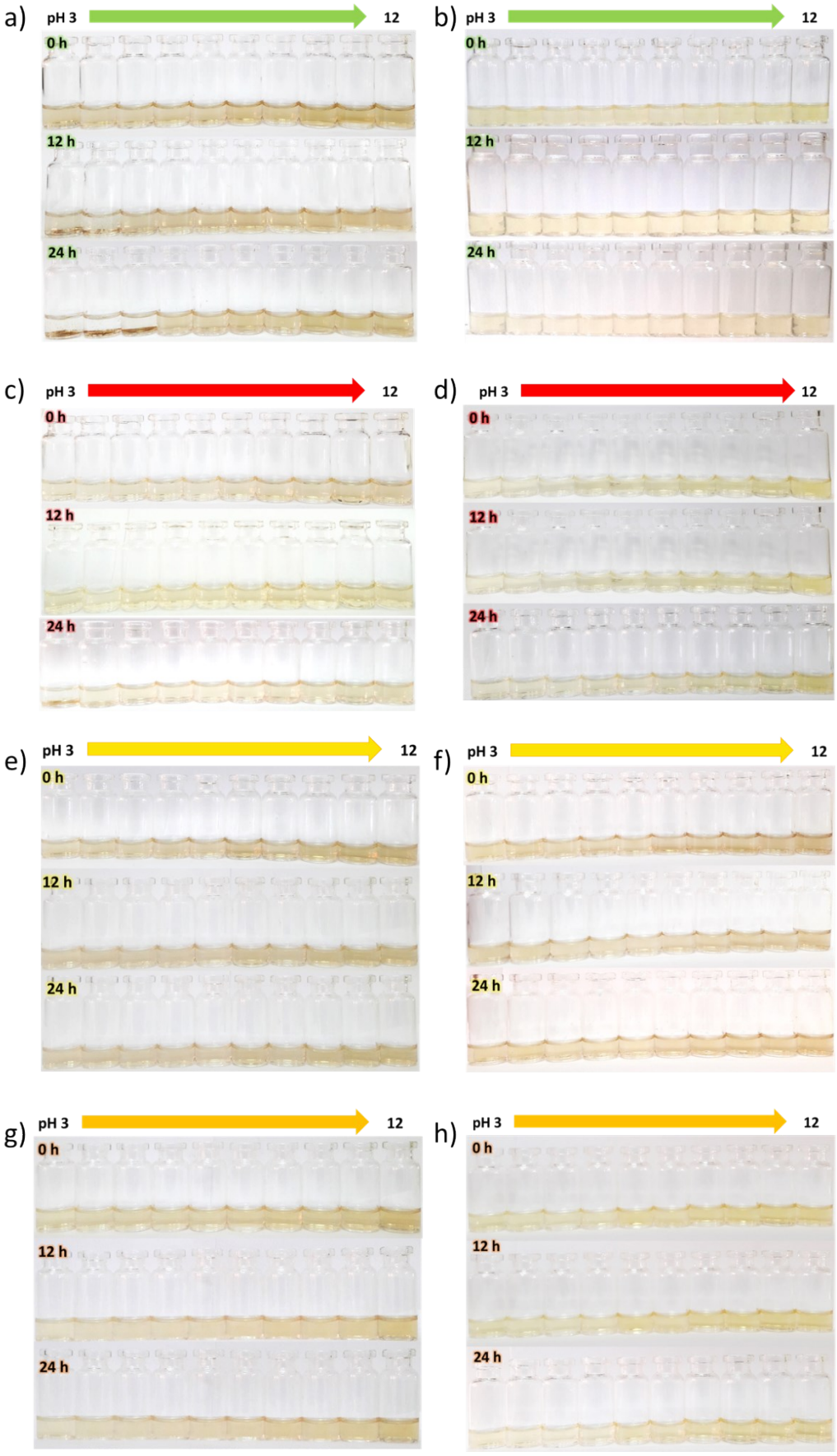

Fig. S5 Stability images of (a) B-CDs1, (b) B-CDs2, (c) N-CDs1, (d) N-CDs2, (e) S-CDs1, (f) S-CDs2, (g) P-CDs1, and (h) P-CDs2 at varied pH conditions.

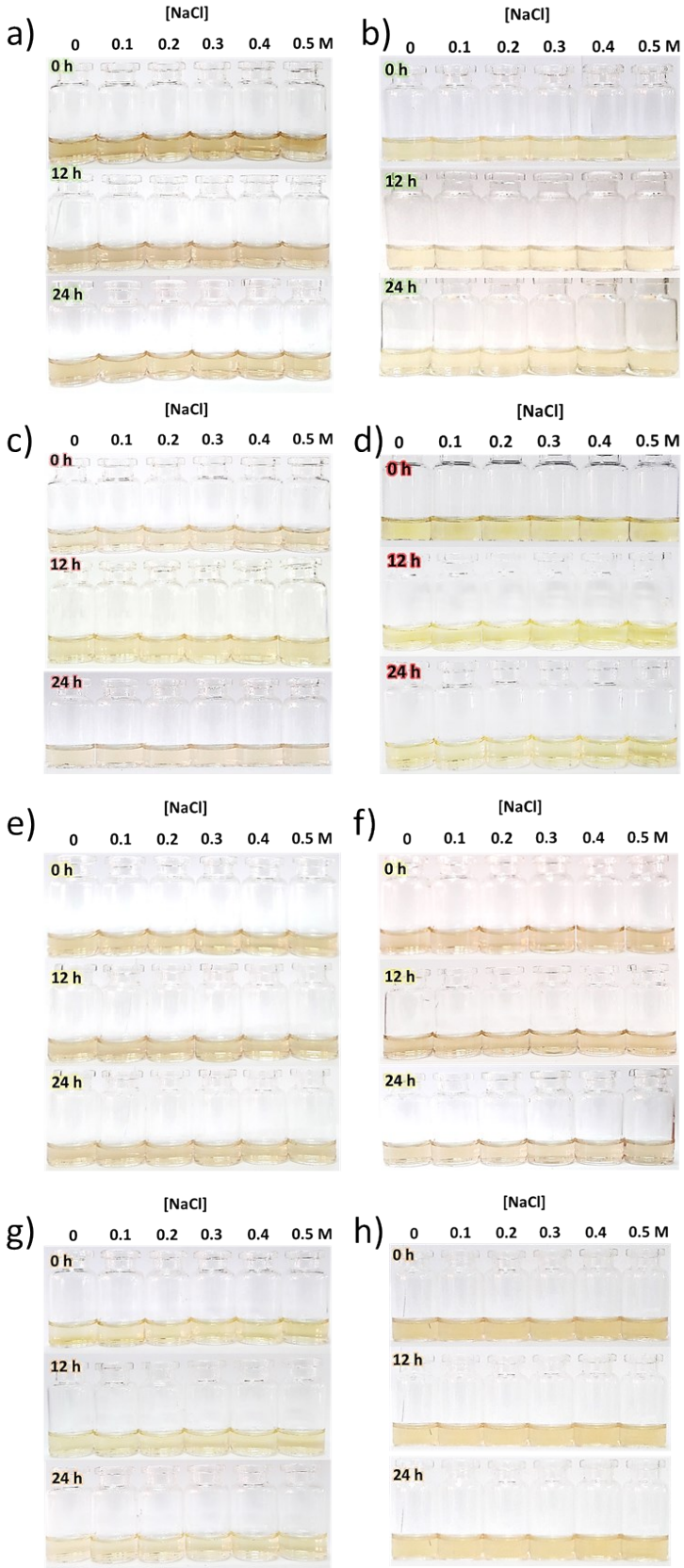

Fig. S6 Stability images of (a) B-CDs1, (b) B-CDs2, (c) N-CDs1, (d) N-CDs2, (e) S-CDs1, (f) S-CDs2, (g) P-CDs1, and (h) P-CDs2 at varied NaCl concentration.

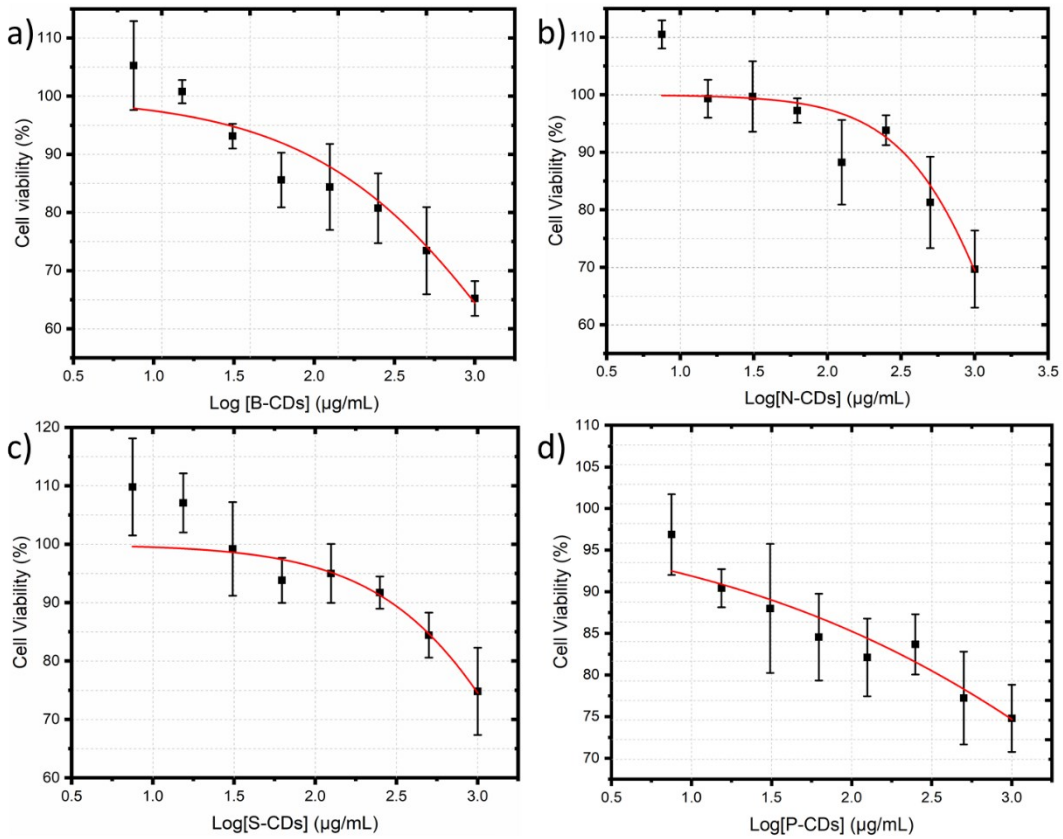

Fig. S7 Cell viability plot of HeLa cancer cells after 24 h incubation (a) B-CDs1, (b) N-CDs1, (c) S-CDs1, and (d) P-CDs1 by the microwave-assisted method. CC_{50} values were plotted on the red fitted curves resulted from doses response mode on Origin software. All data showed as mean ± SD with n=3.

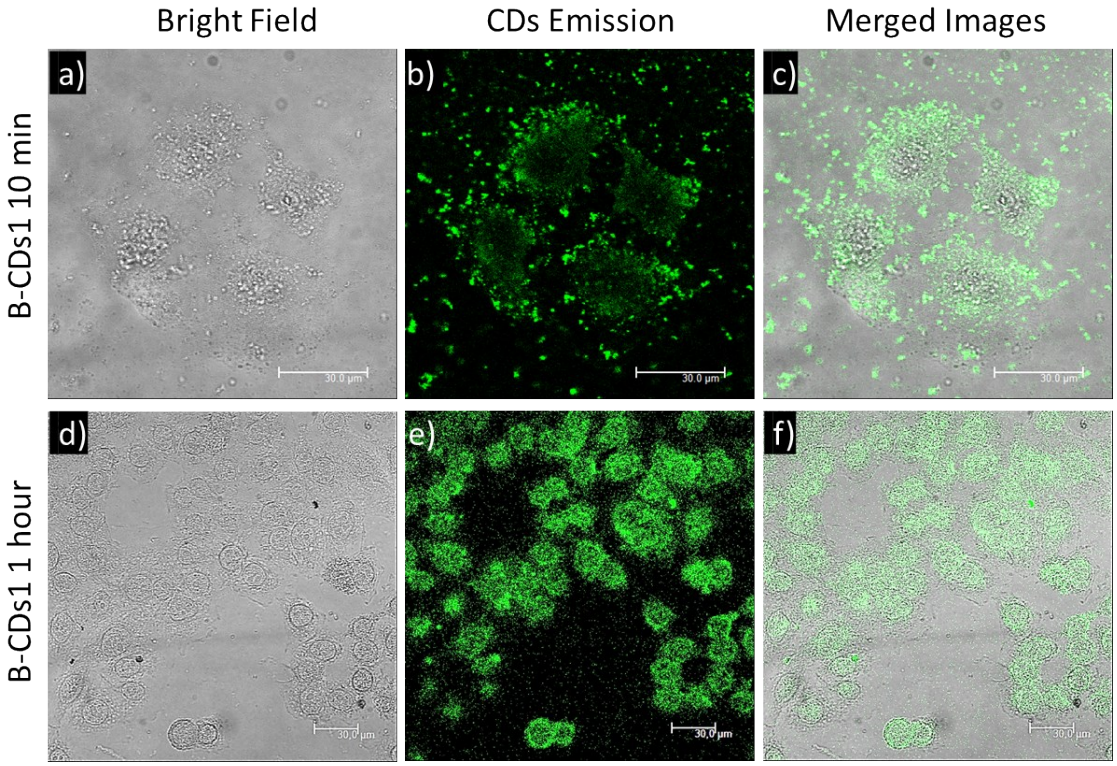

Fig. S8 Photograph CLSM images of HeLa cells after 10 min (a-c) and 1 h (d-f) incubation with B-CDs1.

Table S1. Summary of CDs data from various carbon source and its QY.

Carbon source	Method	Doping	Size (nm)	Color	Emission (nm)	QY (%)	Ref.
Polythiophene derivatives	Hydrothermal	N, S	2-6	Red	680	5.4	[1] and [2]
Citric acid, formamide	Microwave	N	4	Red	640	22.9	[3]
Pulp-free lemon juice	Solvothermal	N	4.6	Red	631	28	[4]
Citric acid, ethanediamine, formamide	Solvothermal	N	4.1	Red	627	53	[5]
N,N-Dimethyl-, N,N-diethyl-, and N,N-dipropyl-p-phenylenediamine	Solvothermal	N	1-2	Red	637, 642, 645	86	[6]
Citric acid, urea, sodium fluoride	Microwave	N, F	10	Red	600	1.2	[7]
Pulp-free lemon juice, formamide	Solvothermal	N	5.7	Deep-Red	704	31	[8]
Citric acid, urea	Hydrothermal	N	8.4	Red	550	54.3	[9]
sodium citrate, sodium thiosulfate	Hydrothermal	S	4.6	Blue	440	67	[10]
Peach gum polysaccharide (PGP), ethylenediamine	Hydrothermal	N	2−5	Blue	445	28.46	[11]
Citric acid, thiourea, boric acid	Microwave	B,N,S	3.5	Blue	450	25.8	[12]
Citric acid, boric acid (B-CDs1)	Furnace	B	8.63	Blue	440	31.92	Present study
Citric acid, nitric acid (N-CDs1)	Furnace	N	7.47	Blue	440	31.44	Present study
Citric acid, sulphuric acid (S-CDs1)	Furnace	S	8.97	Blue	440	31.3	Present study
Citric acid, phosphoric acid (P-CDs1)	Furnace	P	7.60	Blue	440	31.37	Present study
Citric acid, boric acid (B-CDs2)	Microwave	B	9.35	Blue	455	32.96	Present study
Citric acid, nitric acid (N-CDs2)	Microwave	N	9.11	Blue	467	32.49	Present study
Citric acid, sulphuric acid (S-CDs2)	Microwave	S	8.06	Blue	410	32.59	Present study
Citric acid, phosphoric acid (P-CDs2)	Microwave	P	5.04	Blue	410	32.09	Present study

Table S2. The relative amount of elements in B-CDs2 by XPS analysis.

Regions	Position (eV)	FWHM	Area	Amount (%)
C 1s	532.0	5.306	13512.80	56.85
O 1s	284.6	6.995	6615.56	39.63
B 1s	193.0	3.891	198.87	3.52

Table S3. Summary Data of CDs and its CC_{50} values

CDs type	Cell model	Assays	Incubation time [h]	CC_{50}	Reference
CDP	NIH 3T3 A549 HCT-15	MTT	24	580 μg/mL 408 μg/mL 413 μg/mL	[13]
Gd-CDs	NCI-H446	MTT	24	6.28 mg/mL	[14]
Gd-CDs	U87MG	MTT	24	33.10 μg/mL	[15]
N-GQDs	trypsin	soybean trypsin	1	1.31 μg/mL	[16]
Cu-NCDs	HepG2	MTT	6	812.96 μg/mL	[17]
GQDs	HepG2	MTT	24	12 μg/mL	[18]
GQD-VO(p-dmada)	MDCK HepG2	MTS	48	62.20 μM 231.7 μM	[19]
Ox-bCD NP	RAW264.7	MTT	12	>1000 μg/mL	[20]
β-CD-CDs	293T	MTT	24	4.8 μg/mL	[21]
DPP CDs CTS CDs	HepG2	MTT	12	820 μg/mL 1318 μg/mL	[22]
B-CDs1	HeLa	CCK-8	1	5289.15 μg/mL	Present Study
N-CDs1	HeLa	CCK-8	1	9217.56 μg/mL	Present Study
S-CDs1	HeLa	CCK-8	1	3725.18 μg/mL	Present Study
P-CDs1	HeLa	CCK-8	1	6710.52 μg/mL	Present Study
B-CDs2	HeLa	CCK-8	1	2444.72 μg/mL	Present Study
N-CDs2	HeLa	CCK-8	1	1945.04 μg/mL	Present Study
S-CDs2	HeLa	CCK-8	1	3218.58 μg/mL	Present Study
P-CDs2	HeLa	CCK-8	1	40318.13 μg/mL	Present Study

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