Electronic Supplementary Material (ESI) for Polymer Chemistry.

Supporting Information

Nitrogen-doped carbon dots as visible light initiators for 3D (bio)printing

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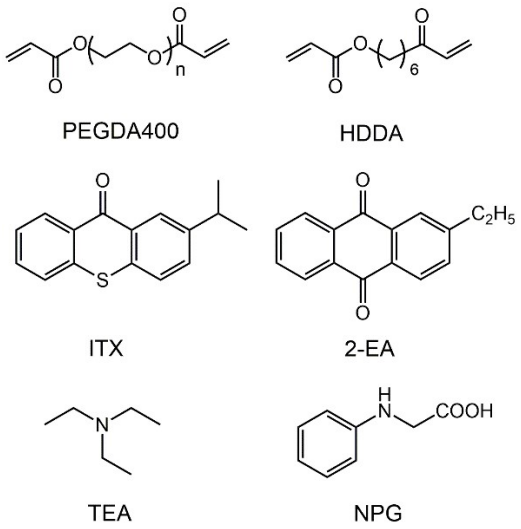

Scheme S1 Chemical structures of compounds used in this study.

Table S1 Composition of raw materials for synthesizing the CDs.

Sample	Urea (g)	Sodium citrate (g)	Citric acid (g)
CD-1	0.202	0.110	0
CD-2	0.202	0.037	0.048

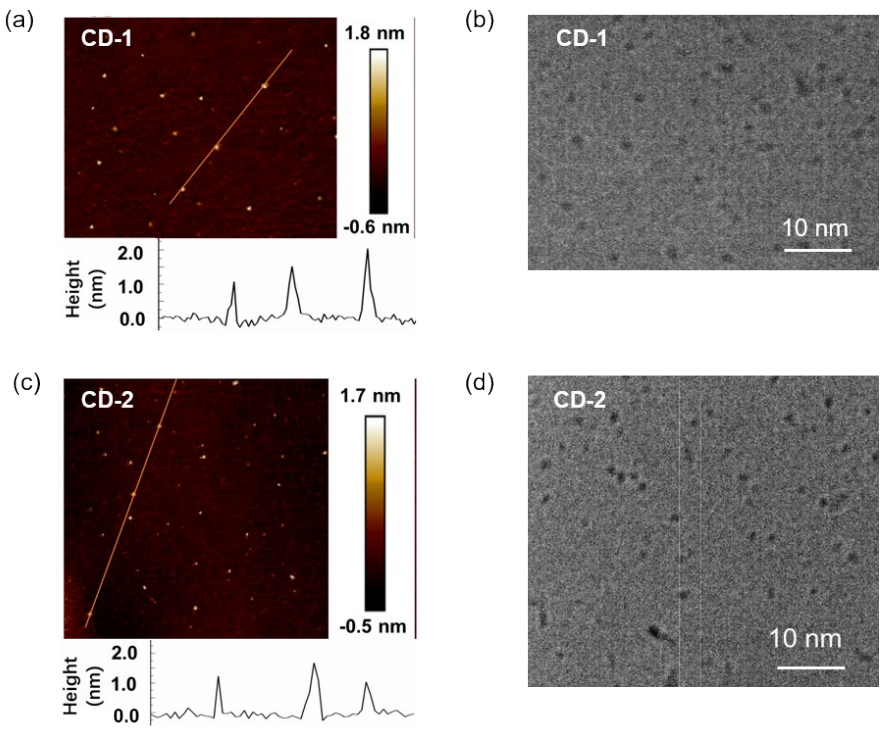

Fig. S1 AFM (a, c) and TEM (b, d) images of CD-1 and CD-2.

Table S2 Atomic ratio of different elements in the samples.

Sample	C (%)	N (%)	O (%)	Na (%)
CD-1	54	17	24	5
CD-2	39	36	23	2

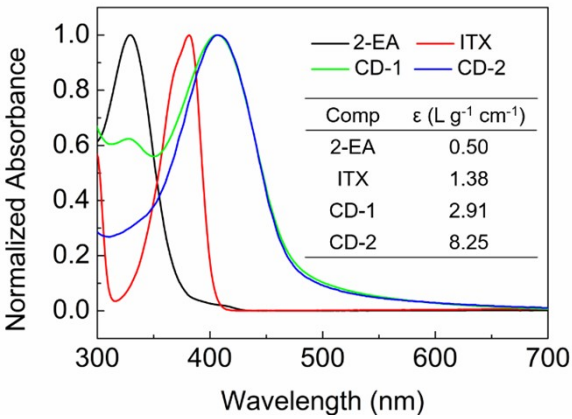

Fig. S2 Normalized UV-vis absorption spectra of different compounds in diluted solutions. The inset shows their extinction coefficient at 405 nm.

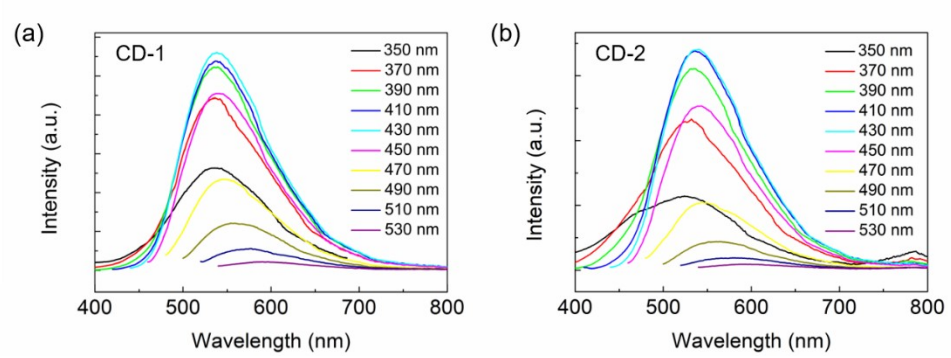

Fig. S3 Fluorescence emission spectra of CD-1 (a) and CD-2 (b) in diluted water solutions under excitation of light with different wavelengths.

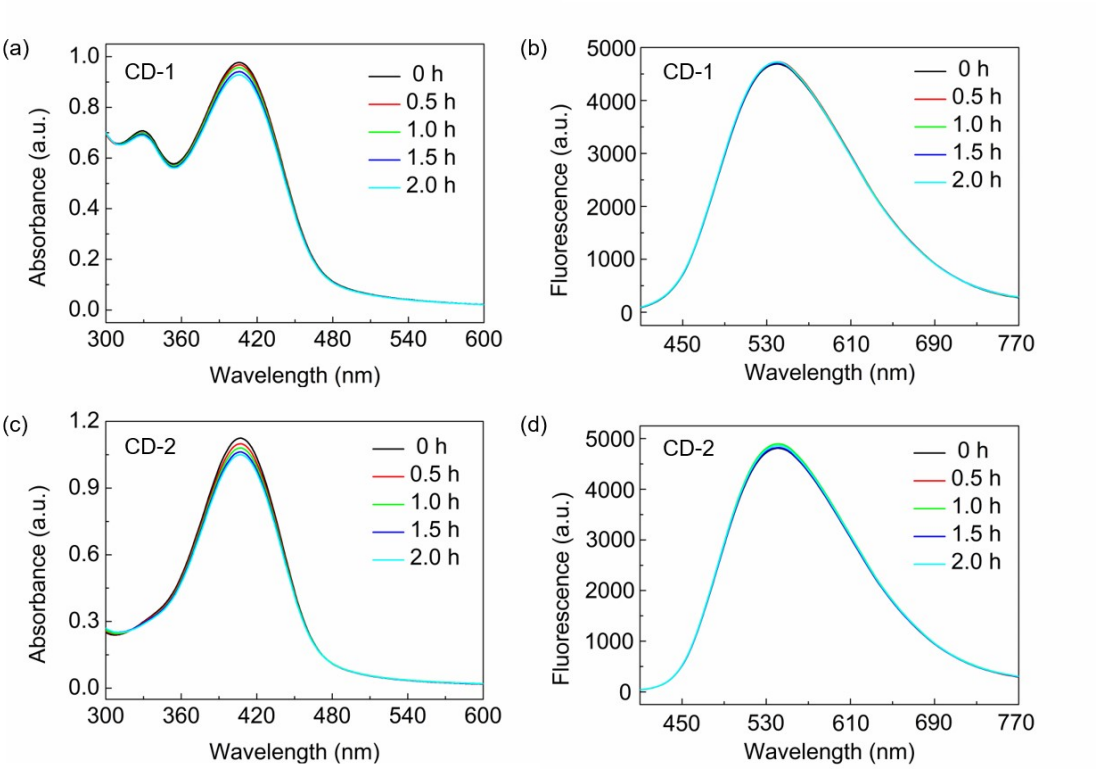

Fig. S4 UV-vis absorption spectra (a, c) and fluorescence emission spectra (b, d) of CDs in aqueous solutions after the irradiation of a 405 nm LED (100 mW/cm^2) for different times.

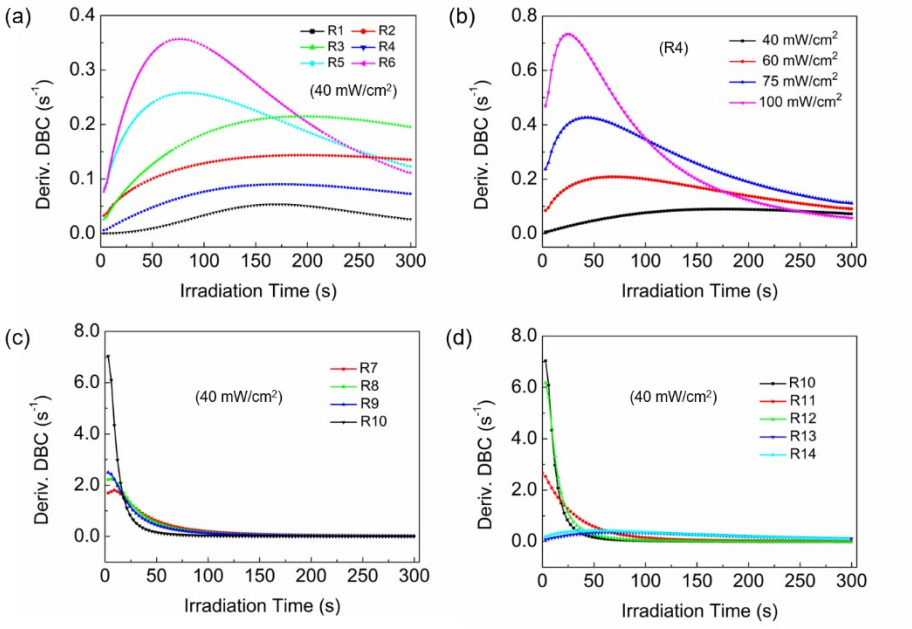

Fig. S5 Derived curves of DBC versus irradiation time of **R1**–**R14** under the irradiation of a 405 nm LED with the same light intensity of 40 mW/cm^2 (a, c and d) and **R4** with different light intensities (b).

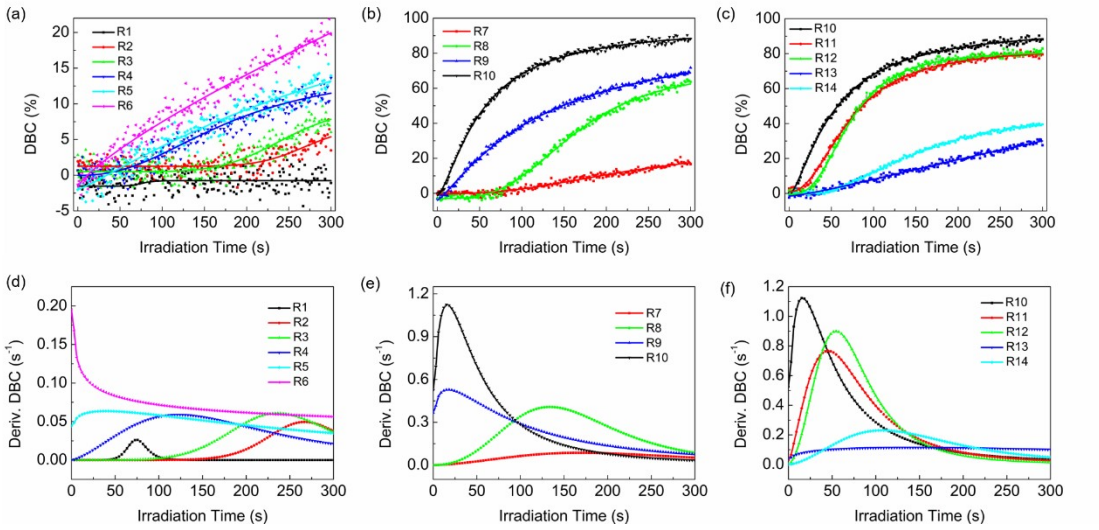

Fig. S6 Photopolymerization kinetics curves of **R1**–**R14** under irradiation of a 450 nm LED (40 mW/cm^2).

Table S3 The formulations of resins **R1**–**R14** and their photopolymerization kinetics data under irradiation of a 450 nm LED.

Resin	CD-1 (mg)	CD-2 (mg)	H_2O (mg)	PEGDA (mg)	TEA (mg)	NPG (mg)	ITX (mg)	2-EA (mg)	DMSO (mg)	DBC (%)	R_{max} (10^{-2} s^{-1})
R1	1.0	0	100	1000	0	0	0	0	0	-	-
R2	2.0	0	100	1000	0	0	0	0	0	5.4	4.9
R3	3.0	0	100	1000	0	0	0	0	0	7.8	6.1
R4	0	1.0	100	1000	0	0	0	0	0	11.5	5.9
R5	0	2.0	100	1000	0	0	0	0	0	13.2	6.8
R6	0	3.0	100	1000	0	0	0	0	0	19.9	19.5
R7	1.0	0	100	1000	1.0	0	0	0	0	17.4	8.6
R8	1.0	0	100	1000	0	1.0	0	0	0	62.4	40.7
R9	0	1.0	100	1000	1.0	0	0	0	0	68.8	52.9
R10	0	1.0	100	1000	0	1.0	0	0	0	88.4	112.3
R11	0	0	0	1000	1.0	0	1.0	0	100	79.9	76.7
R12	0	0	0	1000	0	1.0	1.0	0	100	80.3	89.5
R13	0	0	0	1000	1.0	0	0	1.0	100	30.0	11.4
R14	0	0	0	1000	0	1.0	0	1.0	100	39.5	23.0

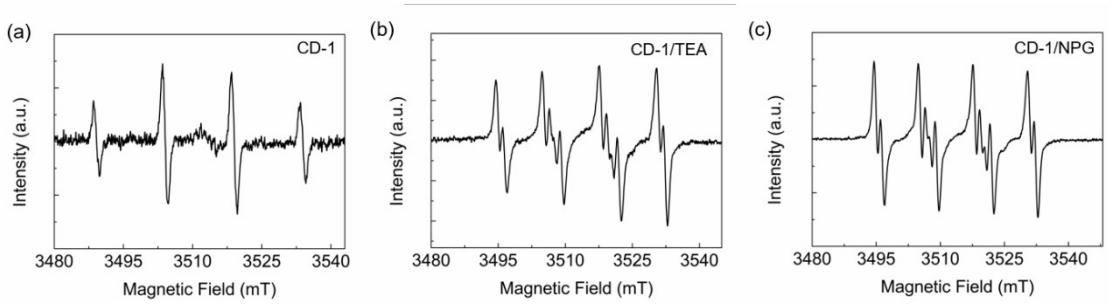

Fig. S7 ESR spectra of (a) CD-1 (1.0 g/L), (b) CD-1/TEA and (c) CD-1/NPG, (1.0/1.0 g/L) in nitrogen-saturated water, the light source is a 405 nm LED (40 mW/cm^2).

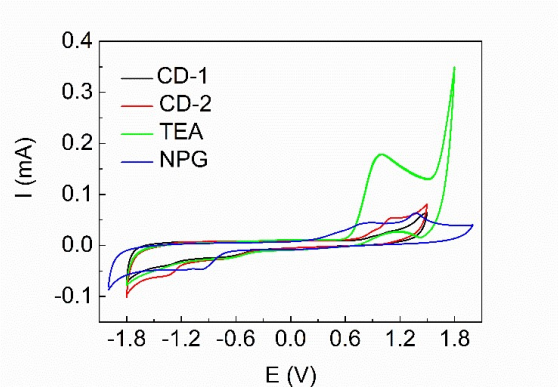

Fig. S8 Cyclic voltammogram curves of CDs and co-initiators in aqueous solution (1.0 g/L).

Table S4 Oxidation and reduction potentials of reactants extracted from the cyclic voltammetry curves.

Compound	E_{ox} (V)	E_{red} (V)	E_s
CD-1	-	-0.70	2.66
CD-2	-	-0.72	2.66
TEA	0.99	-	
NPG	0.89	-	

E_s was the energy difference between the absorption peak and emission peak of the reactants from their UV-vis absorption and fluorescence emission spectra, respectively.

Table S5 Free energy change (ΔG_s) of the four combinations calculated by Rehm-Weller equation.

Photo redox couples	CD-1*/ TEA	CD-1*/ NPG	CD-2*/ TEA	CD-2*/ NPG
ΔG_s (eV)	-0.97	-1.07	-0.95	-1.05

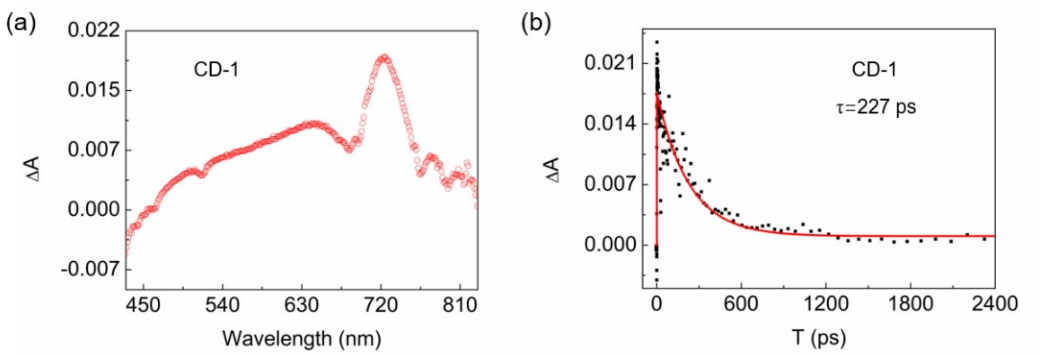

Fig. S9 (a)Transient absorption spectrum of CD-1 in water (1.0 g/L). (b) Exponential fitting curve of time profiles of the absorbance of CD-1 at 720 nm.

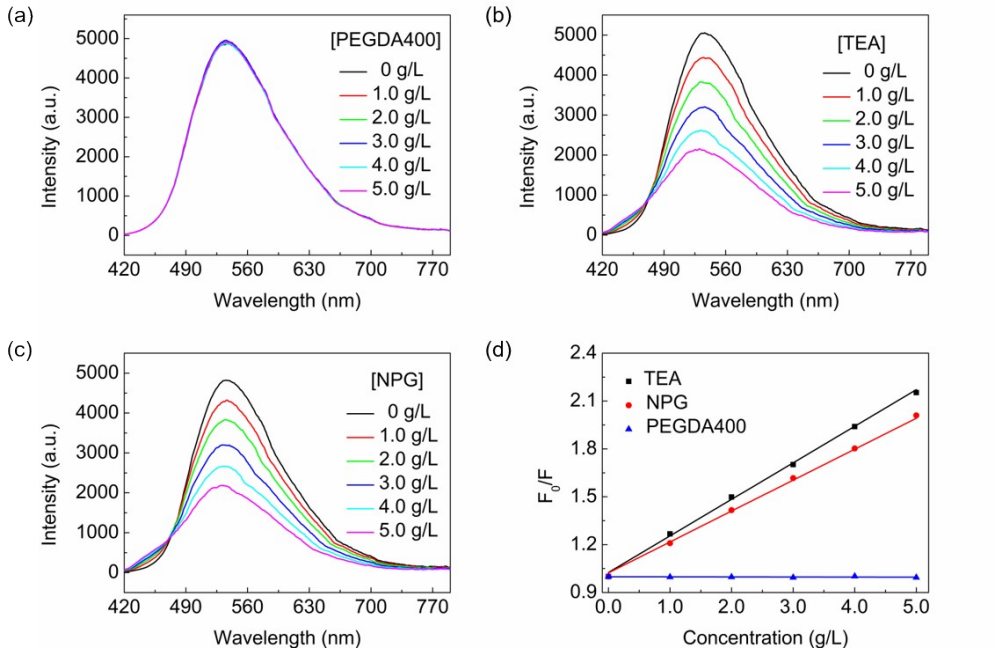

Fig. S10 Fluorescence quenching of CD-1 by different amount of PEGDA400 (a), TEA (b), and NPG (c) in the diluted solutions. (d) Stern–Volmer plots.

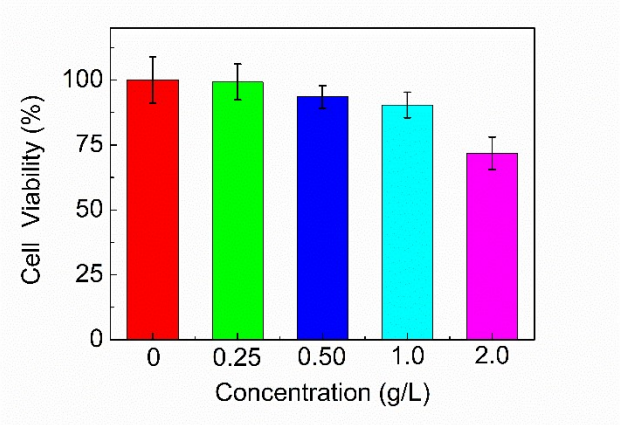

Fig. S11 Relative cell viability of L929 cells after 24 h incubation in NPG solutions.