Electronic Supplementary Material (ESI) for RSC Advances.

Insight into excitation–related luminescence properties of carbon dots: synergistic effect from photoluminescence centers in carbon core and on the surface

Bo Li,[a,b] Yali Guo,[a] Anam Iqbal,[a] Yaping Dong,[b] Wu Li,[b] Weisheng Liu, [a] Wenwu Qin, [a*] Yabin Wang [b*]

a Key Laboratory of Nonferrous Metal Chemistry and Resources Utilization of Gansu Province Lanzhou University, Lanzhou, 730000,P. R. China. Fax: (+86) 931-8912582 E-mail: qinww@lzu.edu.cn

b Qinghai Institute of Salt Lakes, Chinese Academy of Sciences, Xining, Qinghai 810008, P. R. China.E-mail: ybw@isl.ac.cn.

c School of chemistry and Chemical Engineering, Harbin Institute of Technology, Harbin 150001, P. R. China.

Supporting information

Experimental data

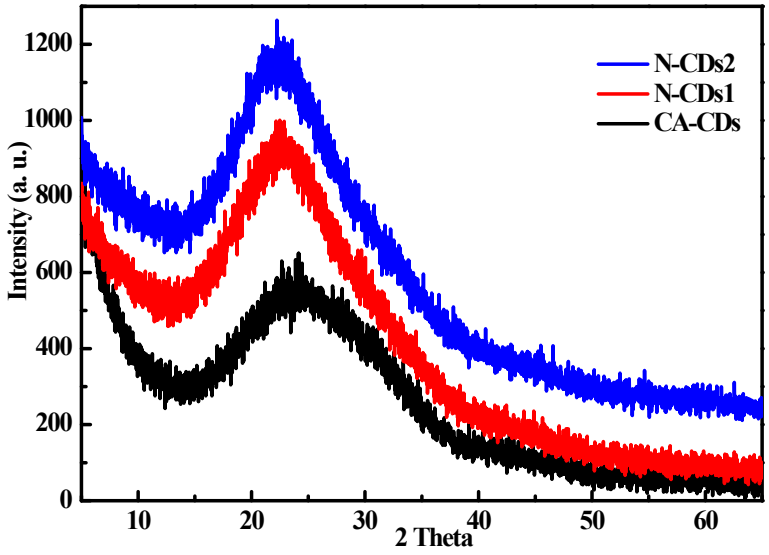

Fig. S1 XRD spectra of prepared CA-CDs, N-CDs1 and N-CDs2.

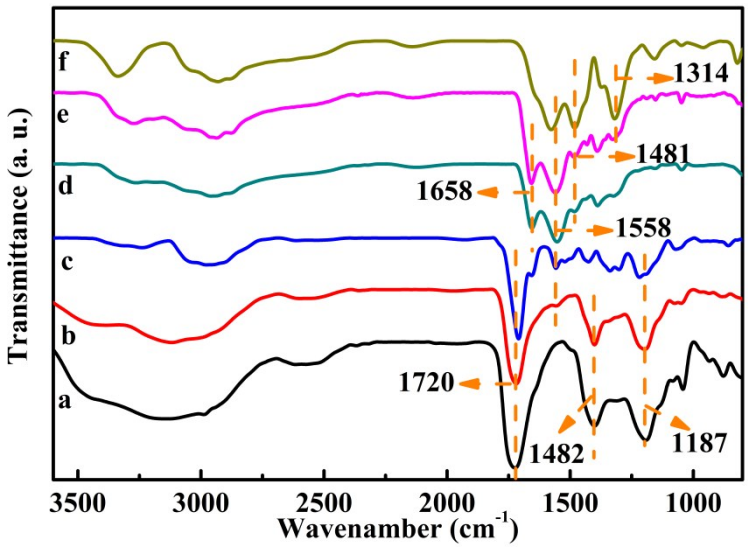

Fig. S2 FT-IR spectra of CDs prepared with different proportion of raw materials (a) 1 mmol CA, (b) 1 mmol CA and 20 μL EDA, (c) 1 mmol CA and 100 μL EDA, (d) 1 mmol CA and 500 μL EDA, (e) 1 mmol CA and 1000 μL EDA, (f) 1 ml EDA, in 10 mL water at 160 °C for 6 h, respectively.

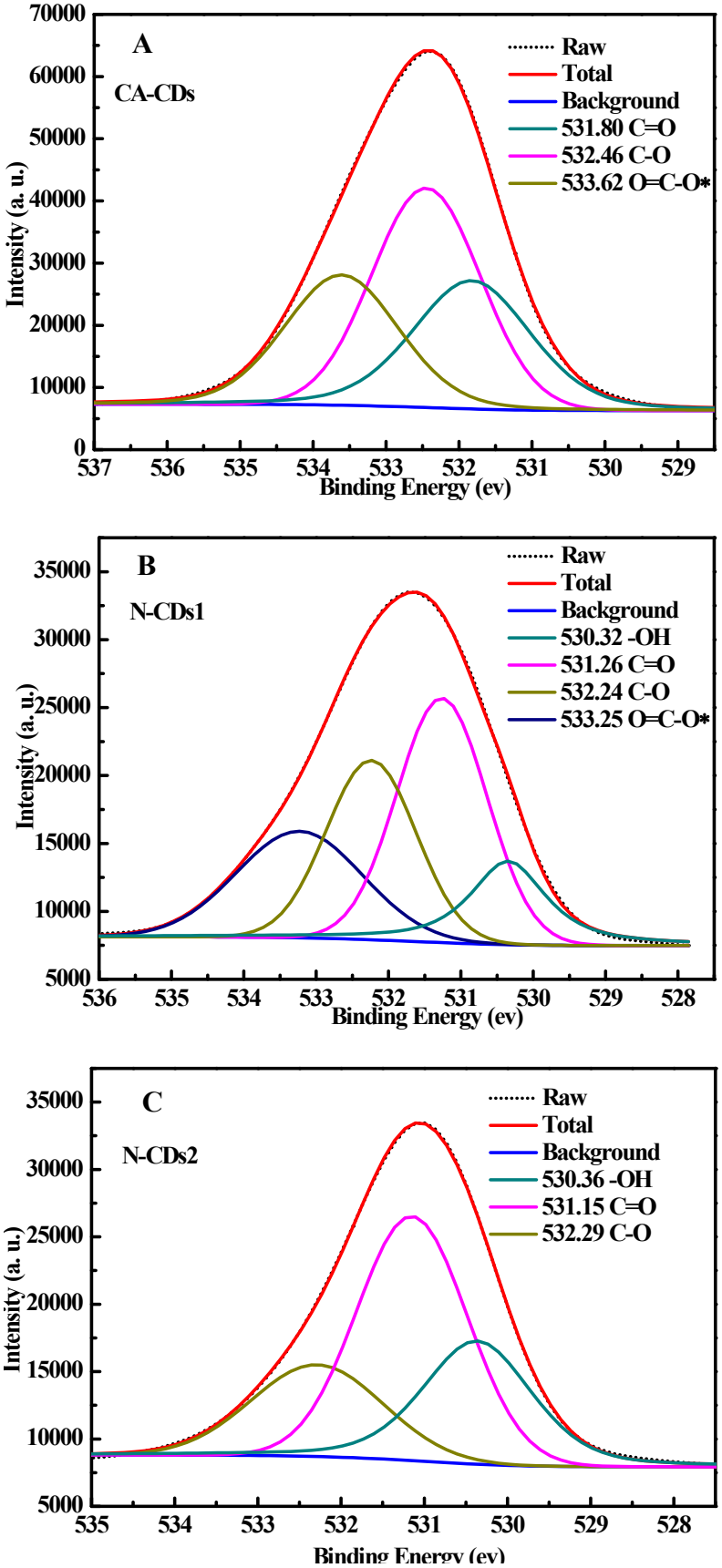

Fig. S3 O1s high–resolution XPS spectra of prepared CA-CDs, N-CDs1 and N-CDs2.

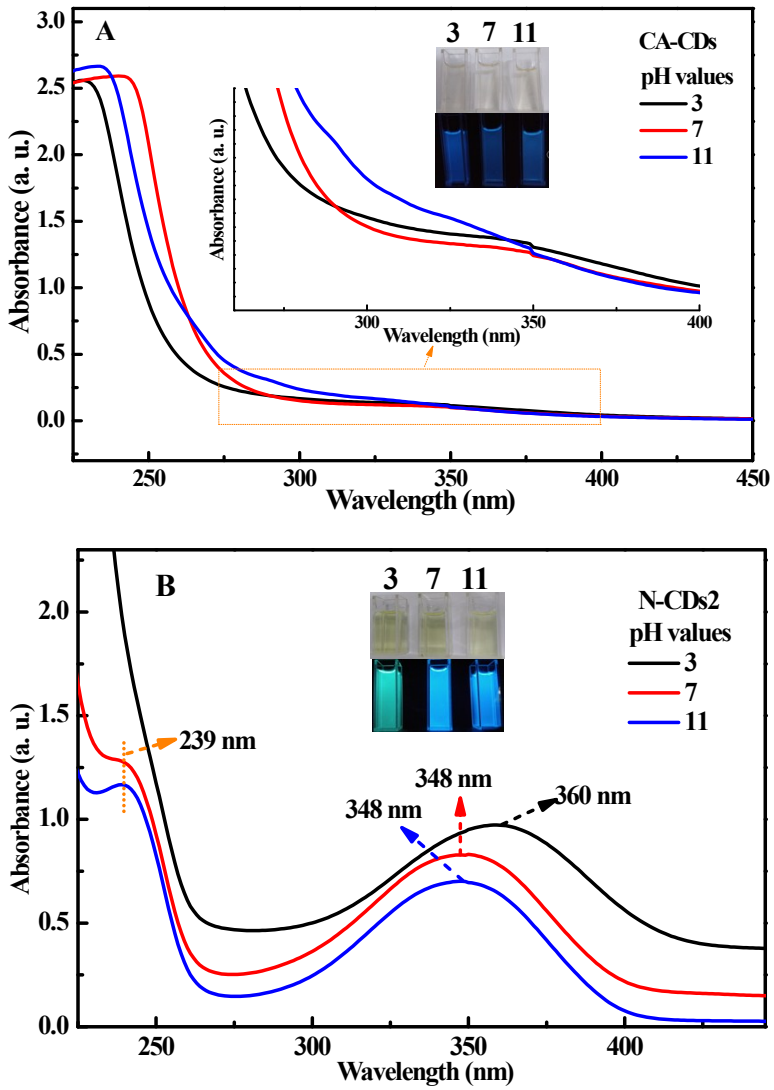

Fig. S4 UV−vis absorption of CA–CDs (A) and N–CDs2 (B) in water solution at pH values of 3, 7 and 11. The insets are the samples under day light and UV lamp (the excitation wavelength is 365 nm).

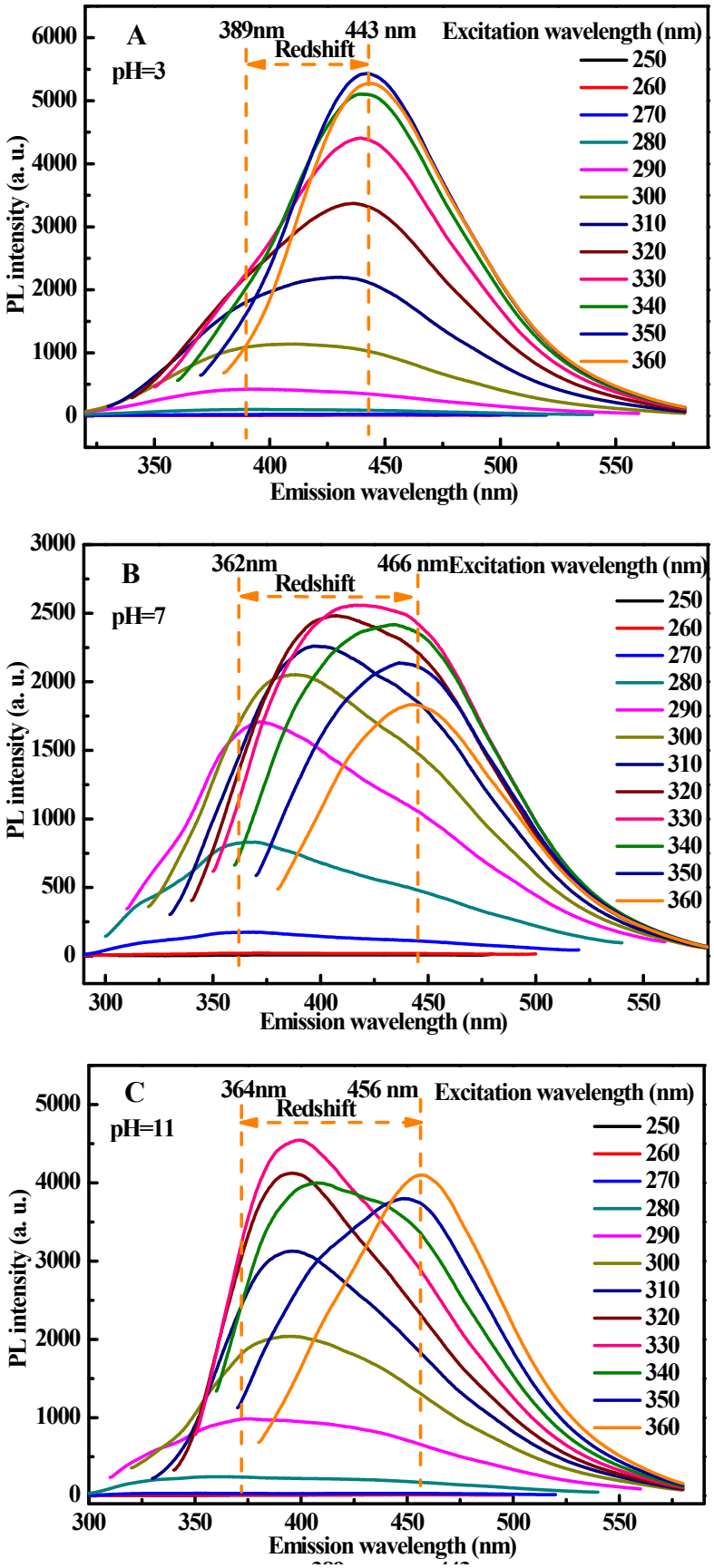

Fig.S5 Fluorescence spectra of CA-CDs at pH 3 (A),7 (B) and 11 (C) with excitation wavelengths from 250 nm to 360 nm.

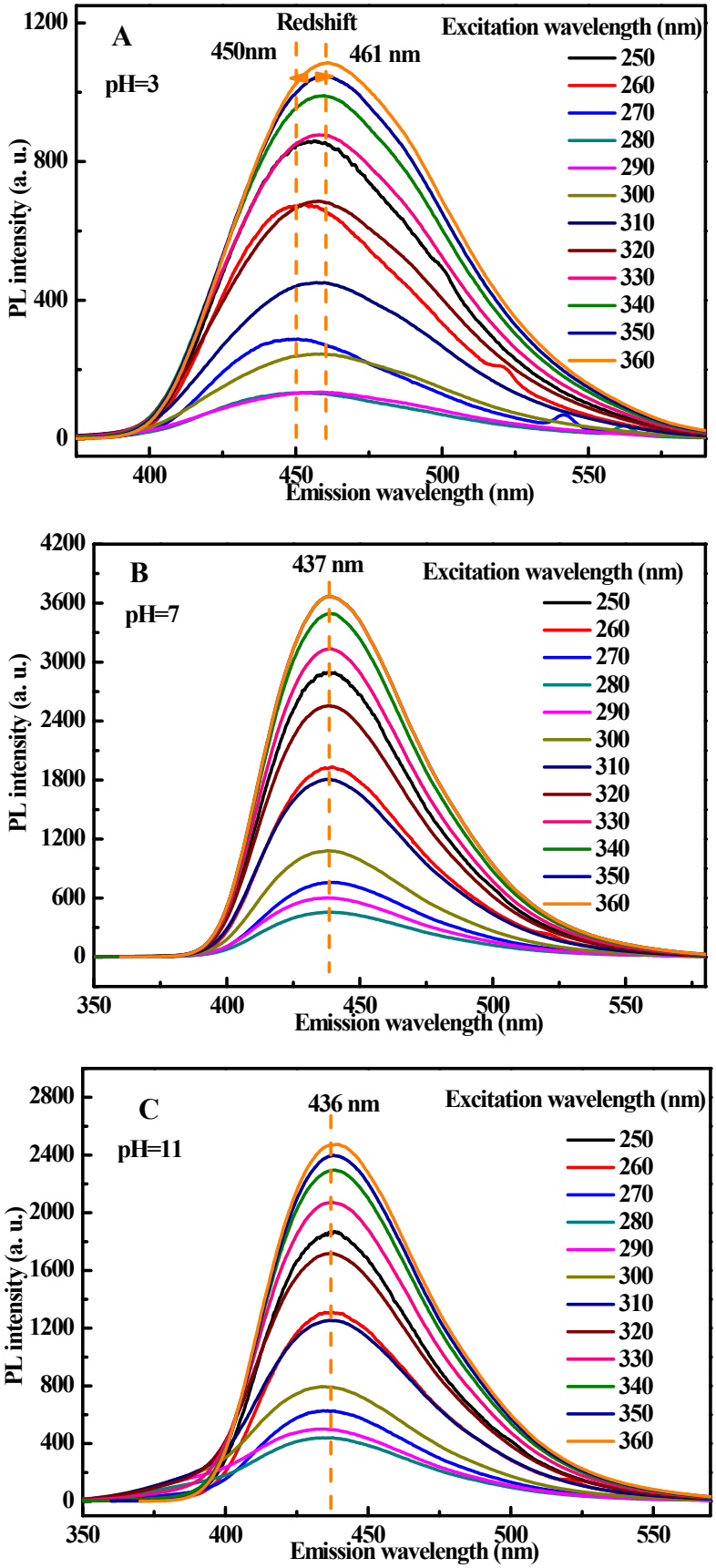

Fig.S6 Fluorescence spectra of N-CDs2 at pH 3 (A), 7 (B) and 11 (C) with excitation wavelengths from 250 nm to 360 nm.

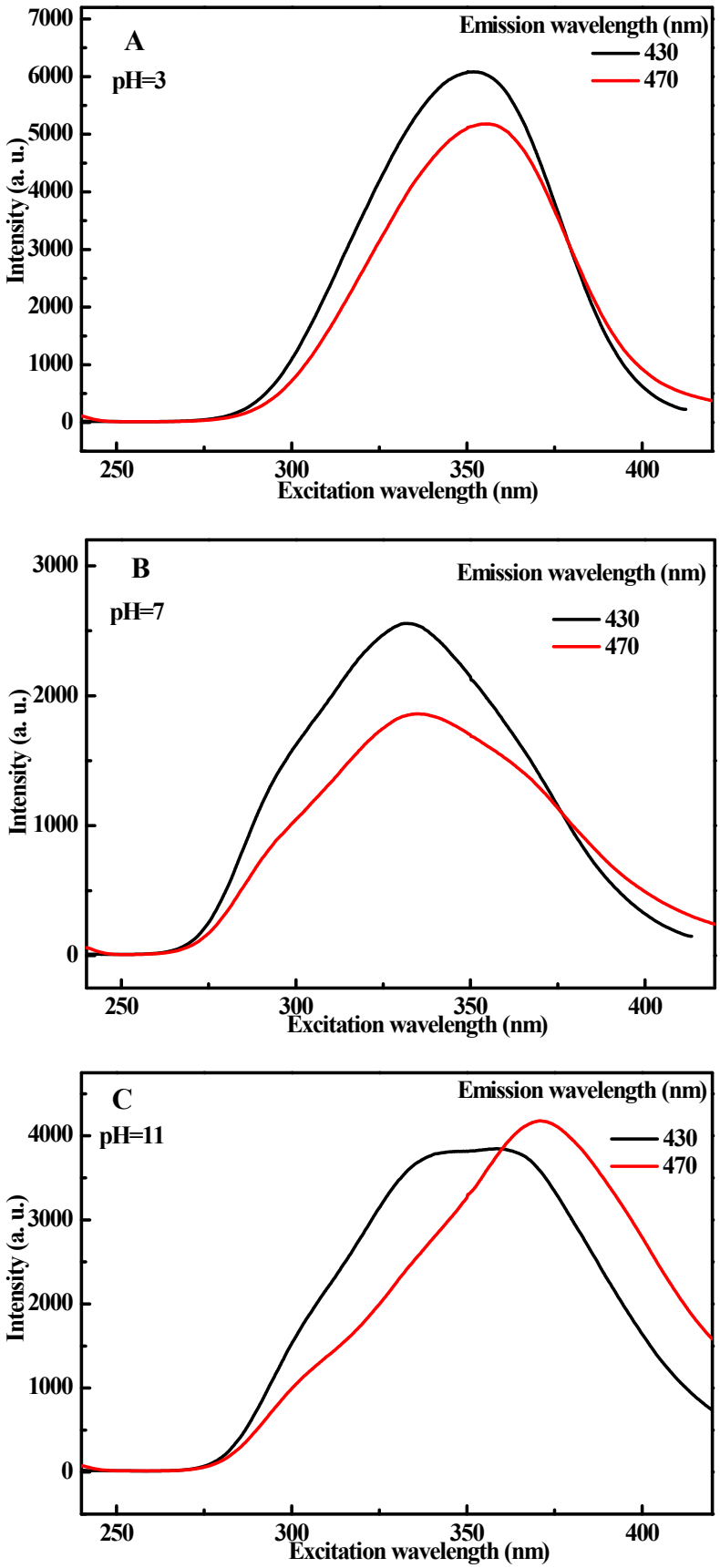

Fig. S7 Excitation wavelengths of CA-CDs at two different emission wavelengths of 430 nm and 470 nm with pH value of 3 (A), 7(B) and 11(C)

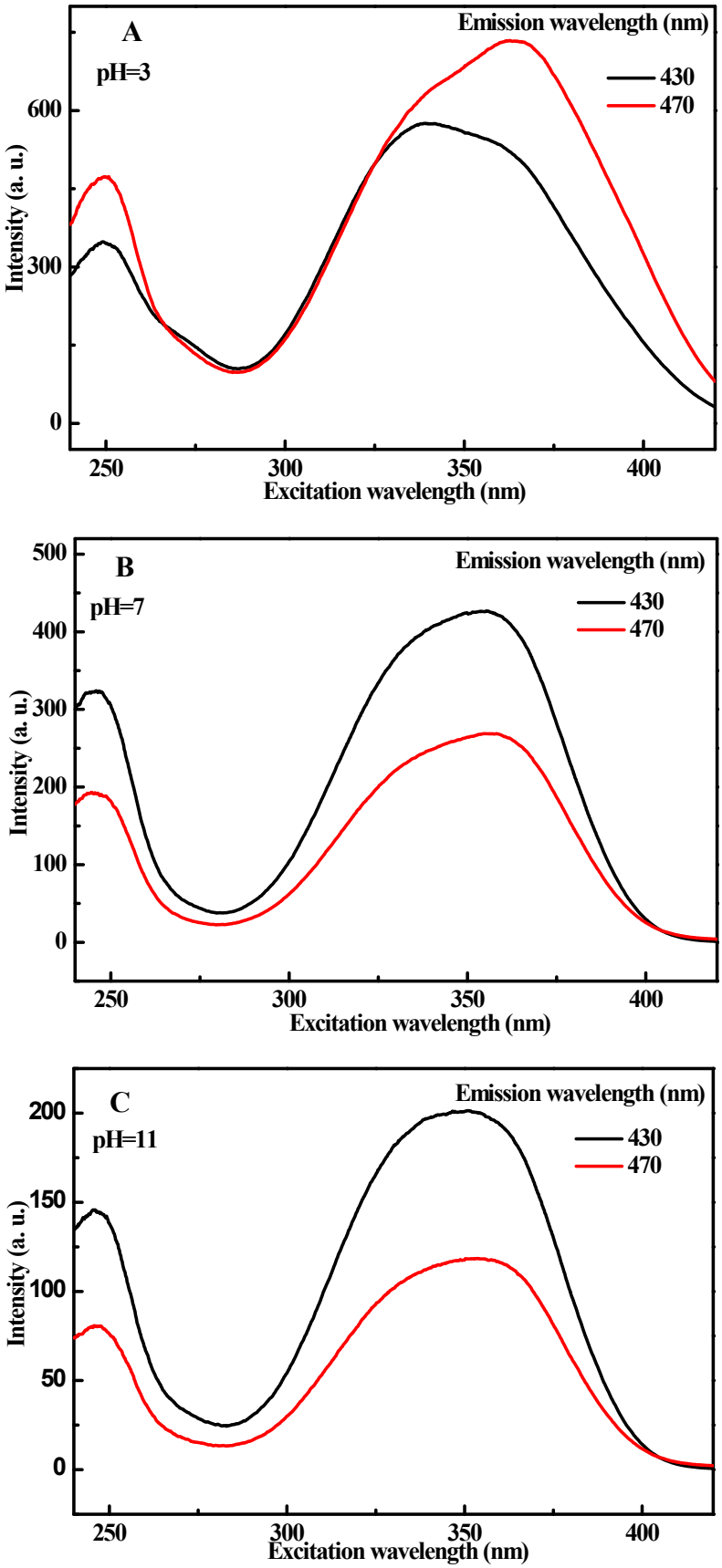

Fig. S8 Excitation wavelengths of N-CDs1 at two different emission wavelengths of 430 nm and 470 nm with pH value of 3 (A), 7(B) and 11(C)

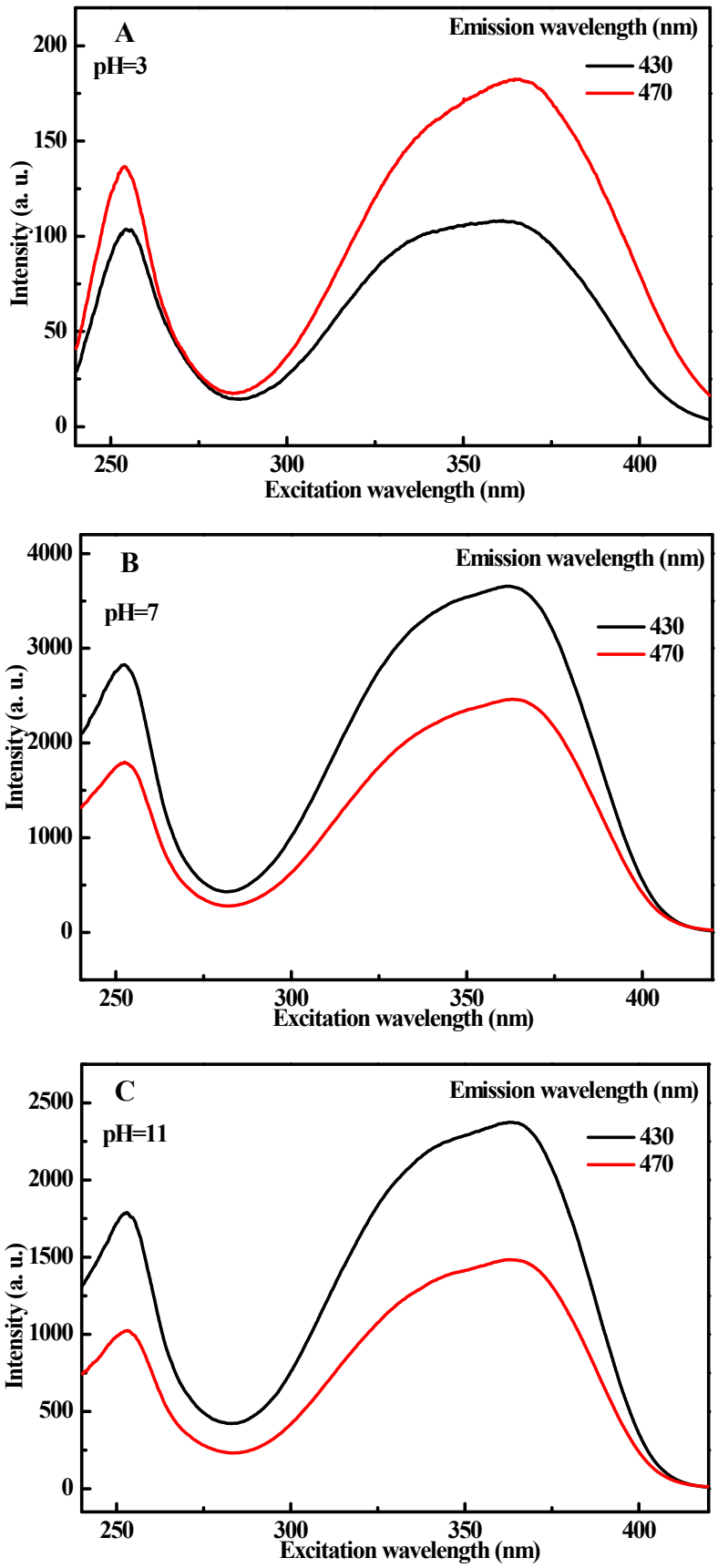

Fig. S9 Excitation wavelengths of N-CDs2 at two different emission wavelengths of 430 nm and 470 nm with pH value of 3 (A), 7(B) and 11(C)

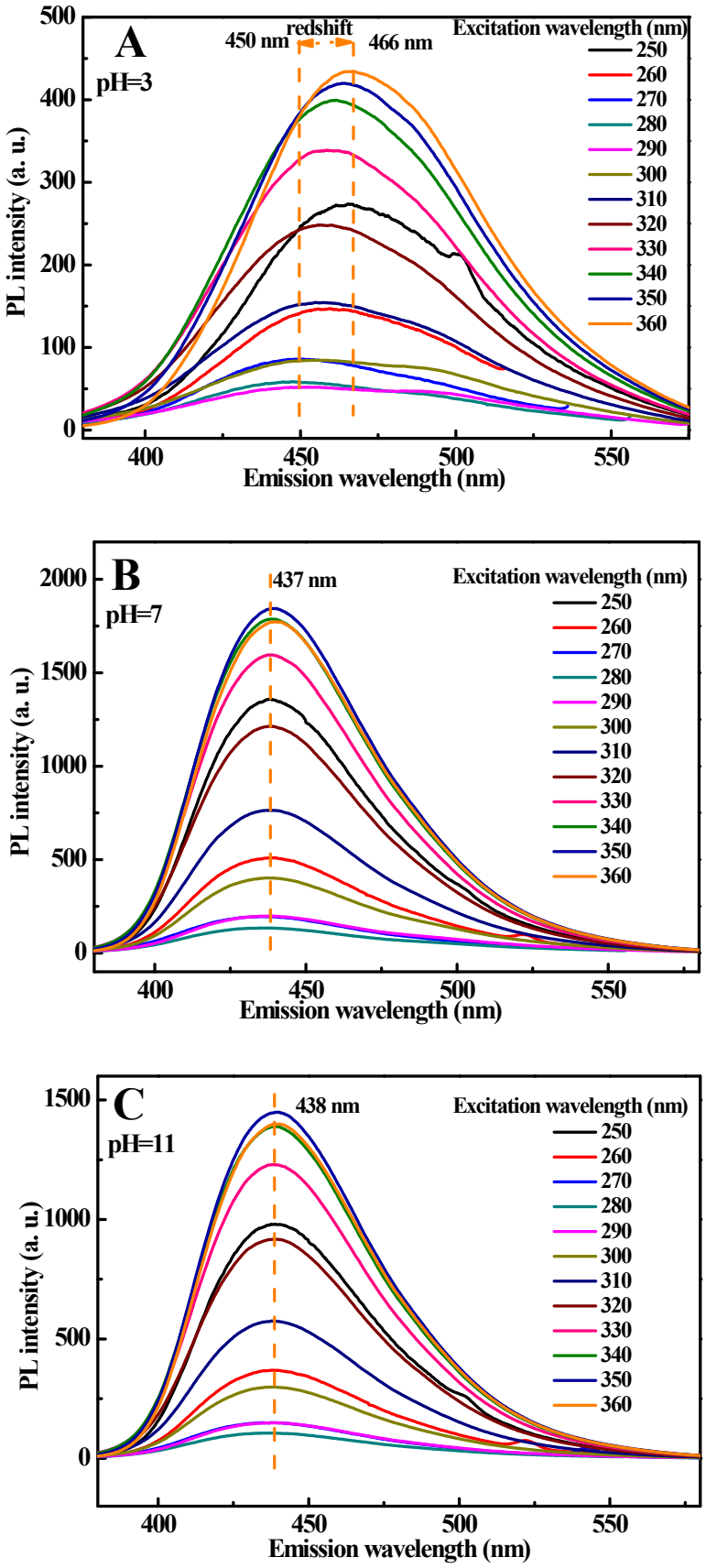

Fig.S10 Fluorescence spectra of CDs prepared with 1 mmol CA and 100 μL EDA at pH 3 (A), 7 (B) and 11 (C) with excitation wavelengths from 250 nm to 360 nm.

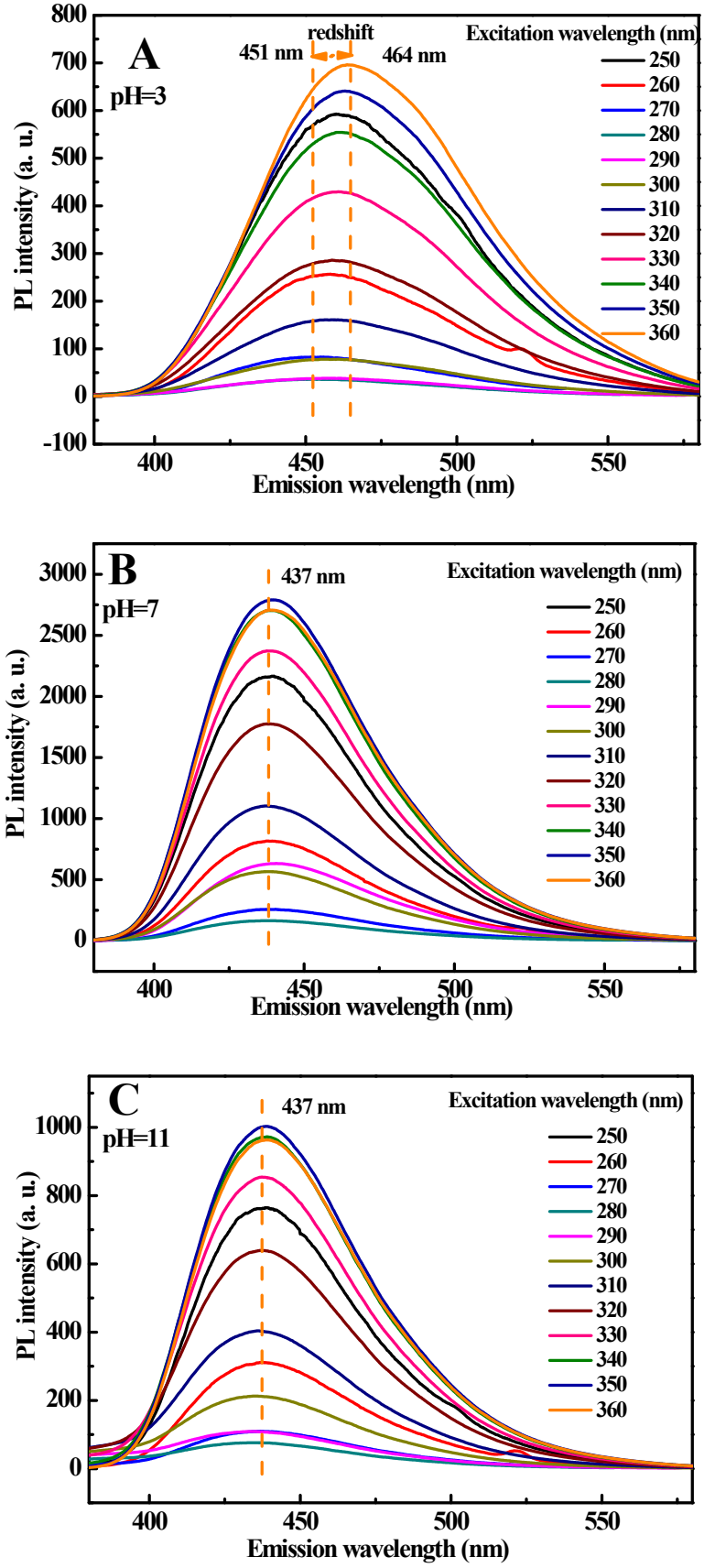

Fig. S11 Fluorescence spectra of CDs prepared with 1 mmol CA and 500 μL EDA at pH 3 (A), 7 (B) and 11 (C) with excitation wavelengths from 250 nm to 360 nm.

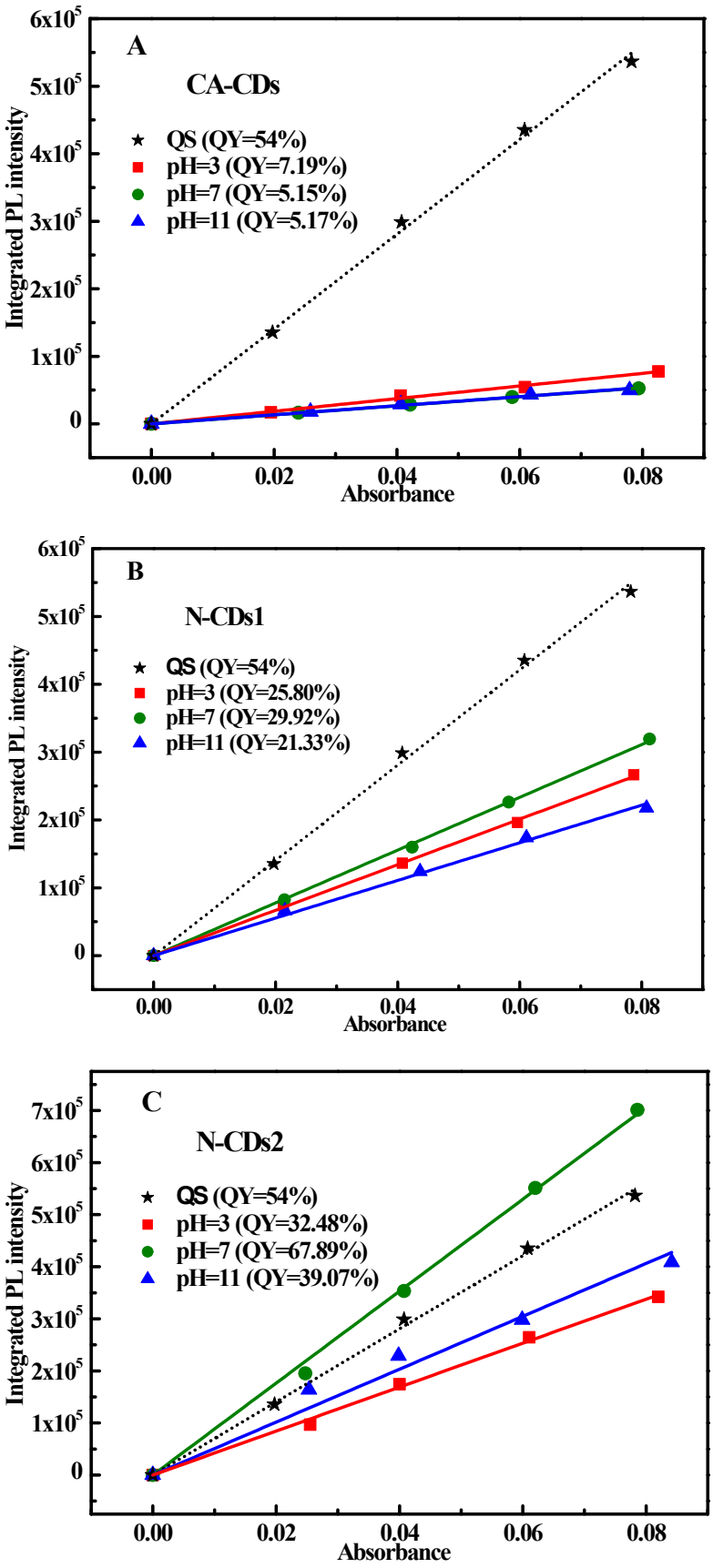

Fig. S12 The PL quantum yield of CA-CDs (A), N-CDs1 (B) and N-CDs2 (C) at pH 3, 7 and 11 with quinine sulfate in 0.1 M H2SO4 as a standard sample.

Tab. S1 XPS component ratio analyses of prepared CDs.

Elements	C	O	N
CA-CDs	**60.14**	**39.86**	**---**
N-CDs1	**65.04**	**24.36**	**10.60**
N-CDs2	**63.88**	**18.67**	**17.45**

Tab. S2 High–resolution XPS analyses of prepared CDs

	C1s					O1s				N1s			
	C-C /C=C	C-N	C-OH	C-O-C /C=N	O-C=O (C=O)	-OH	C=O	C-O	O=C-O*	Pyridinic N	N-H	Pyrrolic N	N-$(C)_3$
CA-CDs	**47.3**	**--**	**27.6**		**25.1**	**--**	**29.9**	**42.1**	**28.0**	**--**	**--**	**--**	**--**
N-CDs1	**45.0**	**16.3**	**15.4**	**9.6**	**13.7**	**14.6**	**36.5**	**26.7**	**22.2**	**--**	**--**	**60.8**	**39.2**
N-CDs2	**43.3**	**27.2**	**10.5**	**10.8**	**8.2**	**22.1**	**49.4**	**28.5**	**--**	**18.4**	**30.0**	**28.3**	**23.4**

Tab. S3 Photophysical properties of prepared CDs. Decay times τ_1, τ_2 and τ_3, relative amplitude (%),average decay times and PL QY%.

CDs	PH	EM (nm)	τ_1 (ns) %	τ_2 (ns) %	τ_3 (ns) %	τ (ns)	x^2	QY %
CA-CDs	3	435	1.18 (23.11)	4.33 (46.07)	11.08 (30.82)	8.24	1.008	7.19
	7	435	0.93 (23.6)	4.25 (50.39)	11.86 (26)	8.43	1.083	5.15
	11	435	0.99 (20.97)	3.92 (63.42)	13.03 (15.61)	7.67	1.031	5.17
N-CDs1	3	460	2.3 (7.45)	6.98 (42.81)	12.66 (49.75)	10.68	1.025	25.80
	7	440	3.80 (9.67)	12.35 (90.33)	--	12.08	1.033	29.92
	11	440	4.03 (9.07)	11.26 (90.93)	--	11.01	1.086	21.33
N-CDs2	3	460	4.99 (39.87)	9.96 (60.13)	--	8.72	1.065	32.48
	7[a]	440	4.31 (1.23)	14.54 (98.77)	--	14.50	1.046	67.89
			14.38 (100)	--	--	14.38	1.067	
	11 [a]	440	2.18 (0.95)	10.32 (99.05)	--	10.30	1.034	39.07
			10.22 (100)	--	--	10.22	1.039	

a: The time-resolved emission of N–CDs2 can be described by a mono-exponential decay function and double–exponentialdecay function at pH value of 7 and 11.

Tab. 4 EDE or EIE PL properties of prepared CDs

pH	EDE or EIE (Fluorescence and up-conversion fluorescence)		
	CA-CDs (N-free)	N-CDs1 (N-doping)	N-CDs2 (N-doping and amino)
3	Strong EDE	Middle EDE	Slight EDE
7	Strong EDE	EIE	EIE
11	Strong EDE	EIE	EIE