Supporting Information

Red Room-temperature Phosphorescence of CDs@Zeolite Composites Triggered by Heteroatoms in Zeolite Frameworks

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Table of contents in Supporting Information:

11. **Figure S11.** The fluorescence spectra (blue line) and phosphorescence spectra (red line) of mother solution (up) and CDs@Mn-LEV (down) excited under 360 nm at 77 K.

12. **Figure S12.** PXRD patterns and phosphorescent emission spectra of CDs@Mn-LEV with different doping amount of Mn.

13. **Figure S13.** Low temperature (77K) and room temperature (298K) phosphorescence spectra of CDs@Mn-LEV and CDs@Zn-CHA composites.

14. **Figure S14.** Phosphorescence intensity ratios of CDs@Mn-LEV from 15 min to 180 min and phosphorescence emissions of CDs@Mn-LEV at the beginning and after 2 months.

15. **Figure S15.** Recyclable thermal-responsive phosphorescence emission of CDs@Mn-LEV from green to red upon heating up from 77K to room temperature.

16. **Table S1.** Fitting parameters of time-resolved phosphorescence decay traces of CDs@Mn-LEV (λ_{ex}=420 nm, λ_{em}=620 nm) and CDs@Zn-CHA (λ_{ex}=300 nm, λ_{em}=500 nm).

17. **Table S2.** Fitting parameters of time-resolved phosphorescence decay traces of CDs@Mn-LEV and the mother solutions under 77 K (λ_{ex}=300 nm, λ_{em}=500 nm).

18. **Table S3.** Fitting parameters of time-resolved phosphorescence decay traces of CDs@Mn-LEV with different doping amount of Mn atoms (λ_{ex}=420 nm, λ_{em}=620 nm).

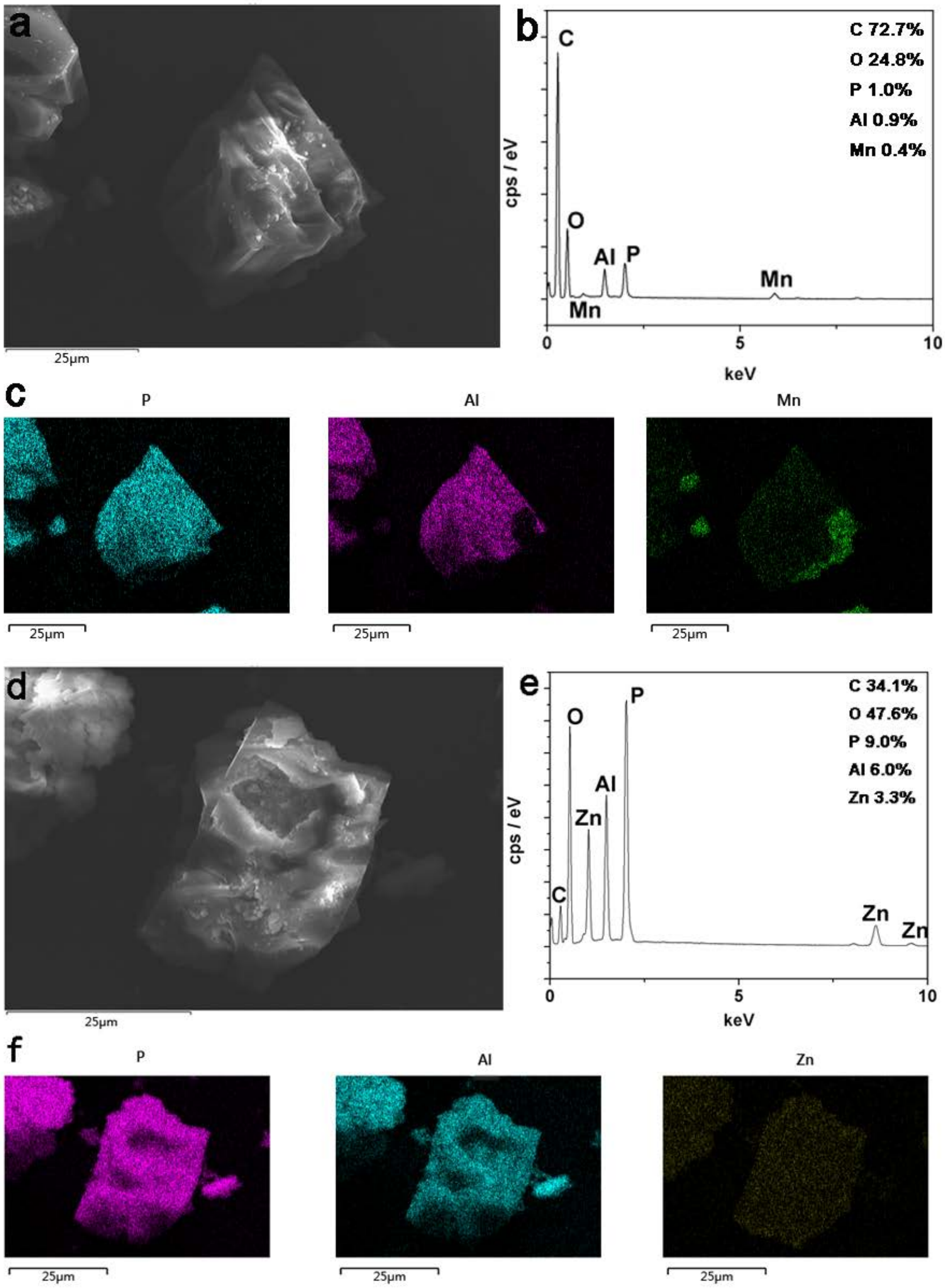


Figure S1. a, b, c) SEM mappings and EDS spectra of CDs@Mn-LEV; d, e, f) SEM mapping and EDS spectra of CDs@Zn-CHA.

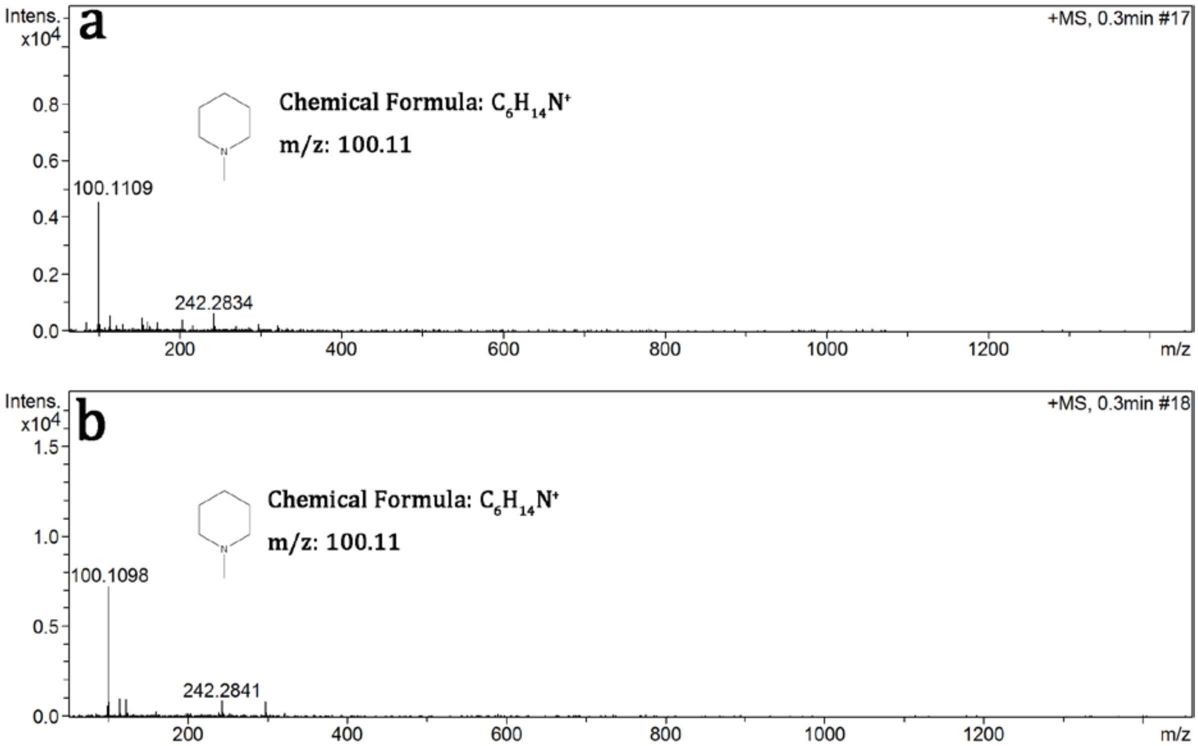


Figure S2. LC-HRMS of dissolved CDs@zeolite composites: a) CDs@Mn-LEV and b) CDS@Zn-CHA.

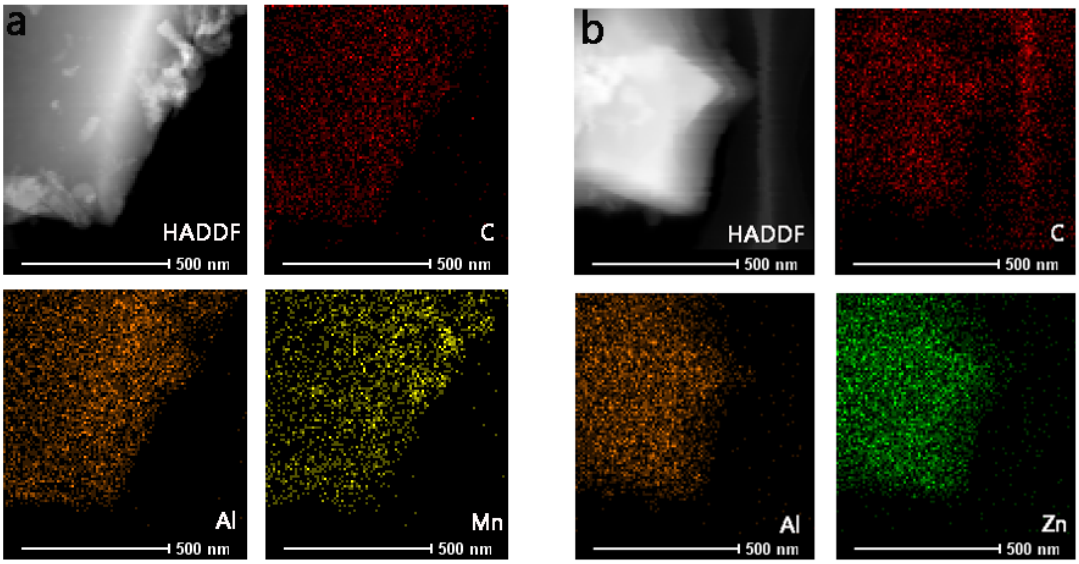


Figure S3. TEM mappings and HADDF STEM images of a) CDs@Mn-LEV and b) CDs@Zn-CHA.

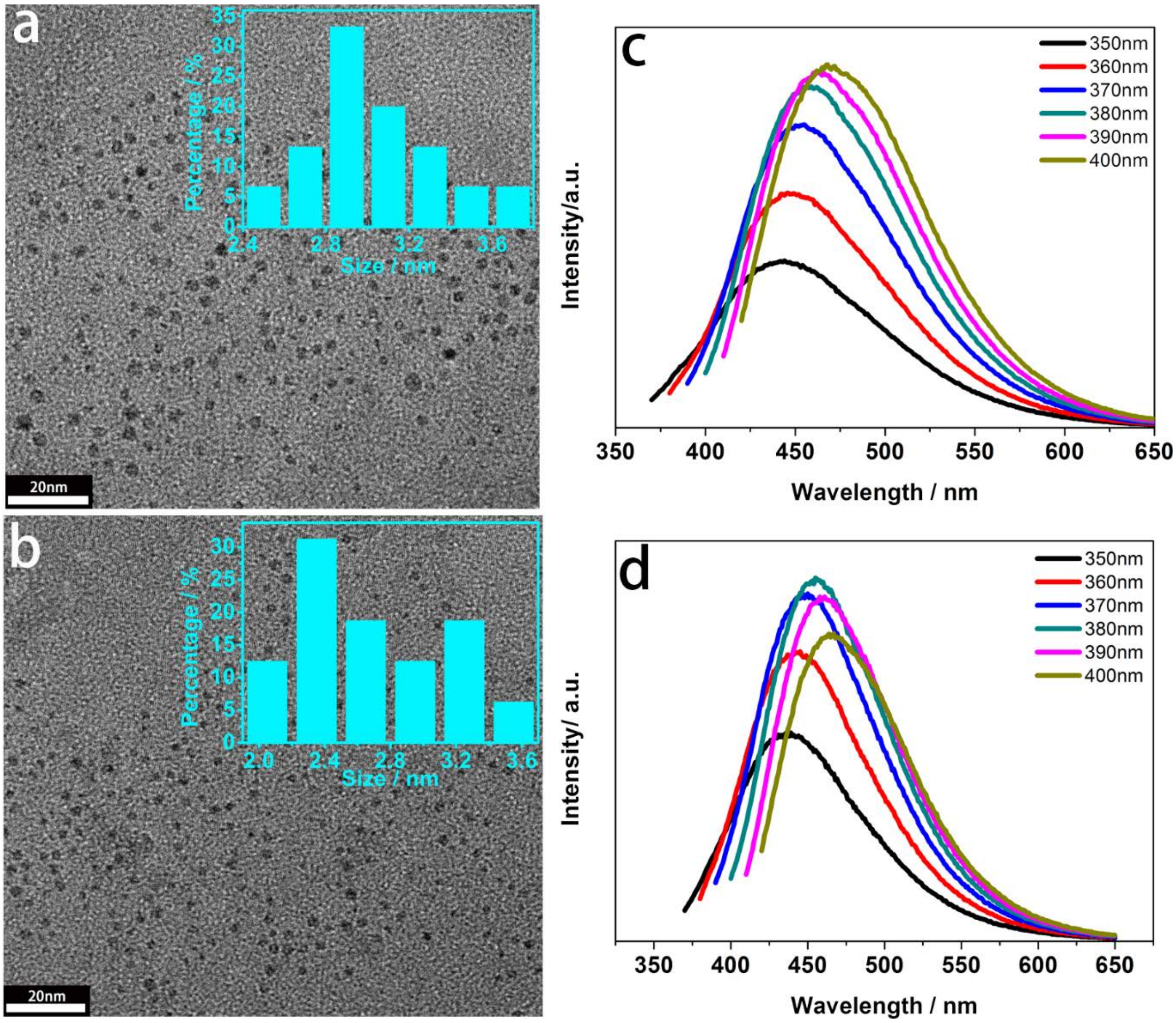


Figure S4. a, b) TEM images and particle diameter distributions of CDs in mother solutions of CDs@Mn-LEV and CDs@Zn-CHA; c, d) fluorescence emission spectra of mother solutions of CDs@Mn-LEV and CDs@Zn-CHA under different excitation.

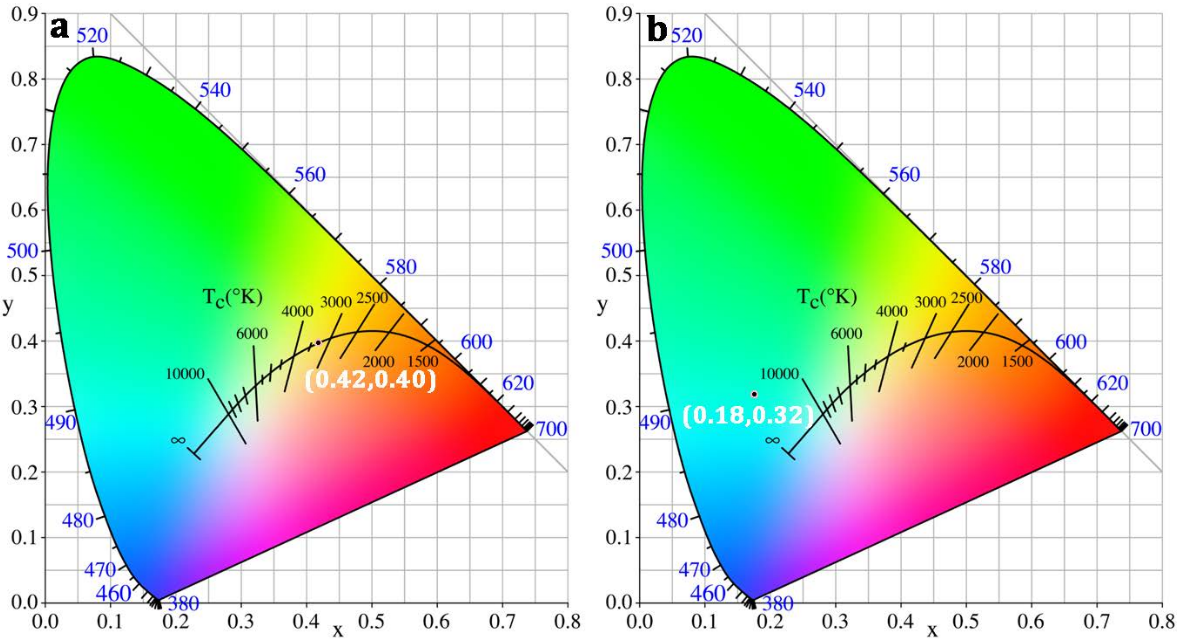


Figure S5. The CIE color coordinates of (a) CDs@Mn-LEV and (b) CDs@Zn-CHA composites.

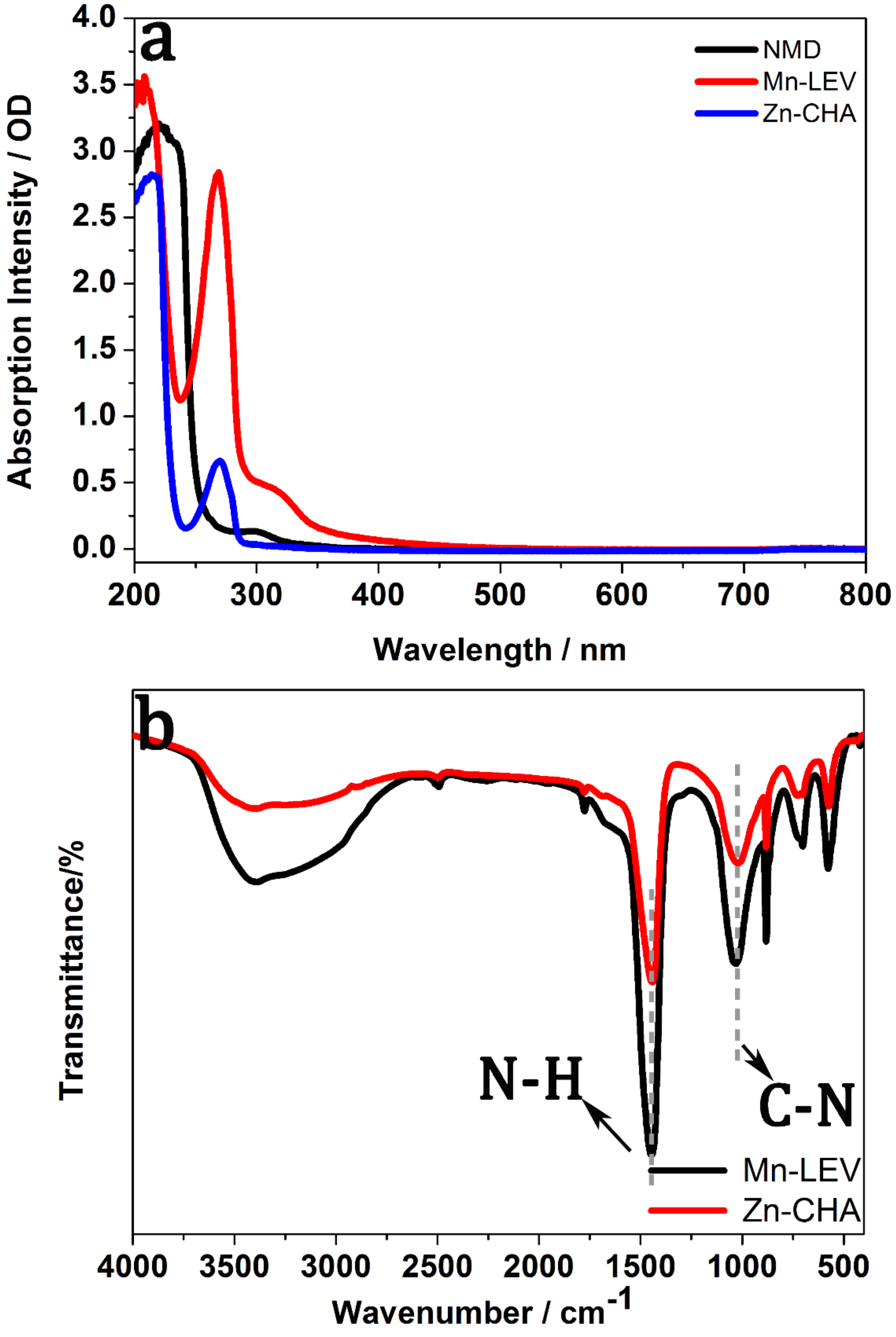


Figure S6. a) UV-vis absorption spectra and b) FTIR spectra of mother solutions obtained from the CDs@Mn-LEV and CDs@Zn-CHA.

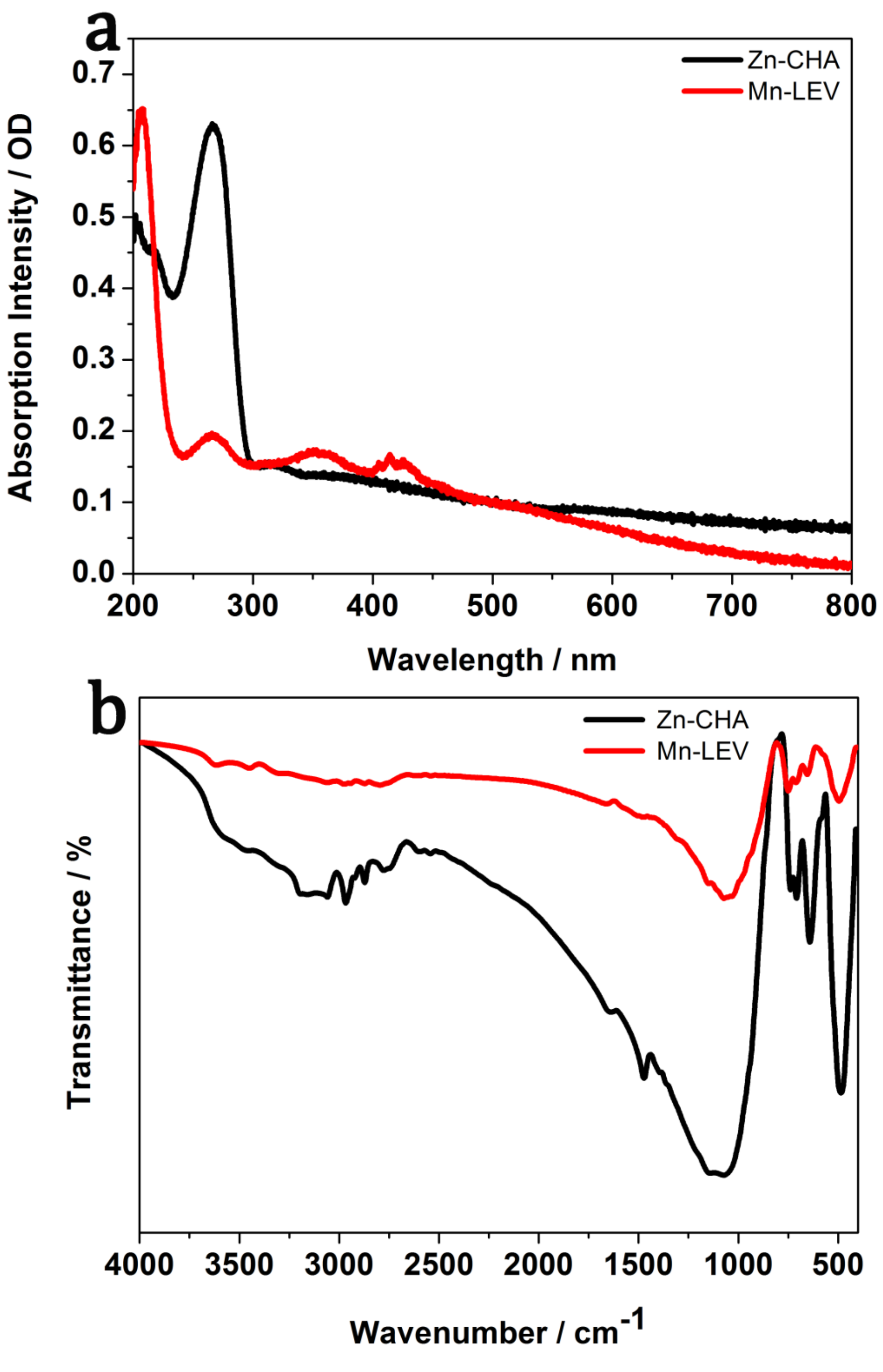


Figure S7. a) UV-vis absorption spectra and b) FTIR spectra of CDs@Mn-LEV and CDs@Zn-CHA composites.

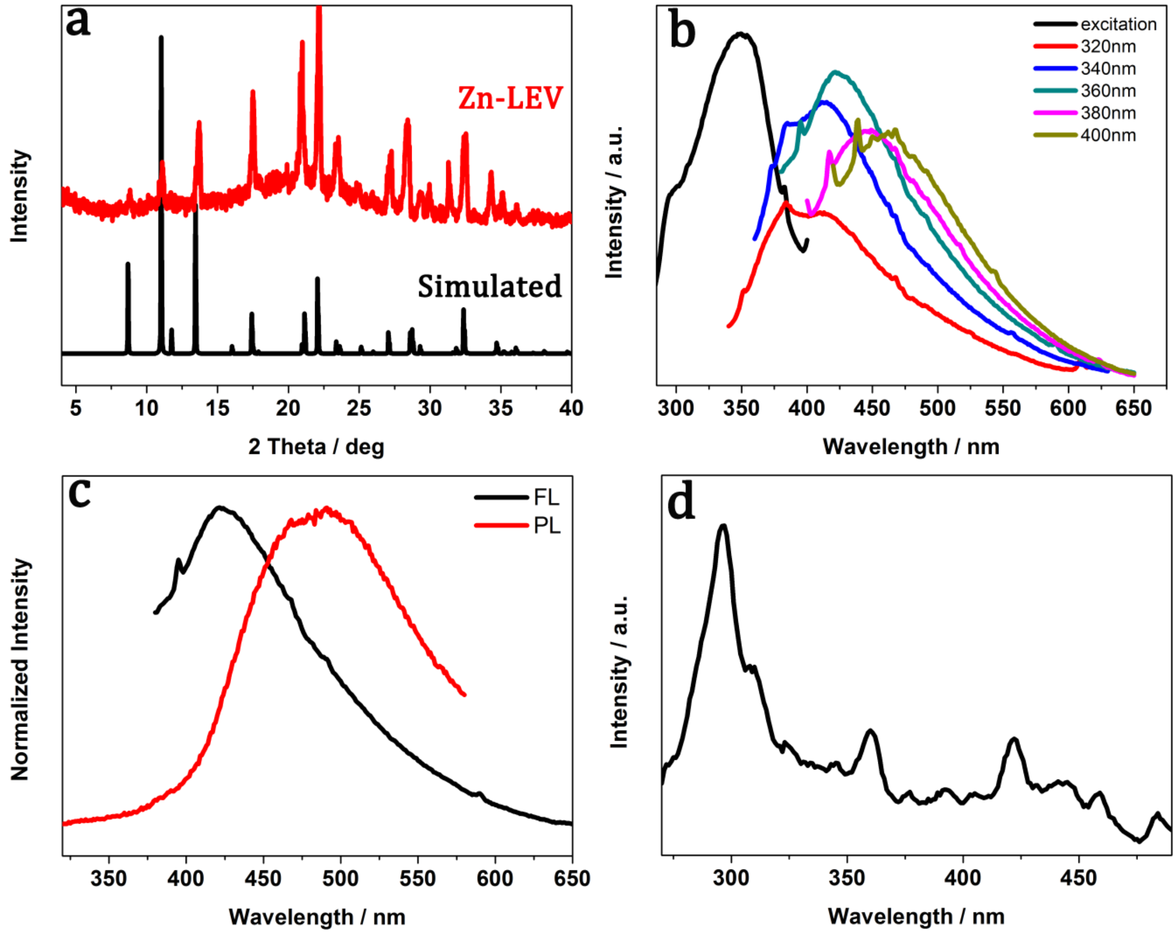


Figure S8. a) PXRD pattern of CDs@Zn-LEV; b) fluorescence excitation spectrum (black line) and emission spectra under different λ_{ex}; c) normalized fluorescence (black line) and phosphorescence (red line) spectra of CDs@Zn-LEV; d) phosphorescent excitation spectrum of CDs@Zn-LEV.

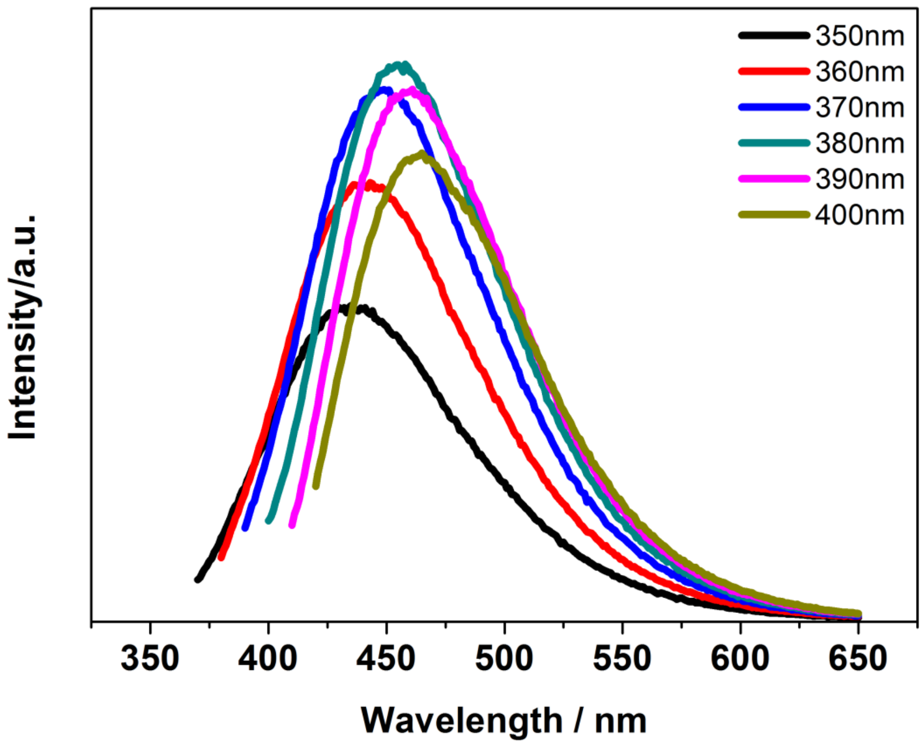


Figure S9. Fluorescence emission spectra of CDs@Zn-LEV mother solution under different excitation wavelength.

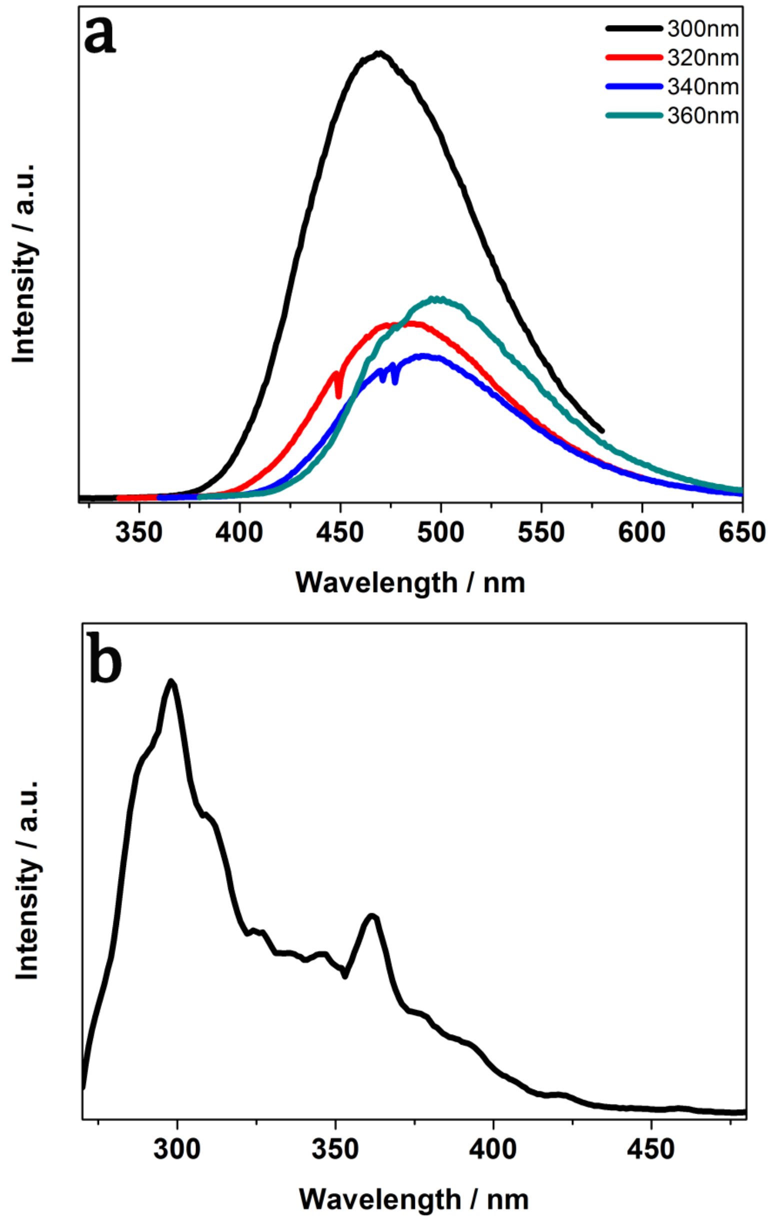


Figure S10. a) low temperature (77K) phosphorescence spectra of mother solution of CDs@Mn-LEV under different excitation; b) low temperature (77K) phosphorescence excitation spectrumof mother solution of CDs@Mn-LEV.

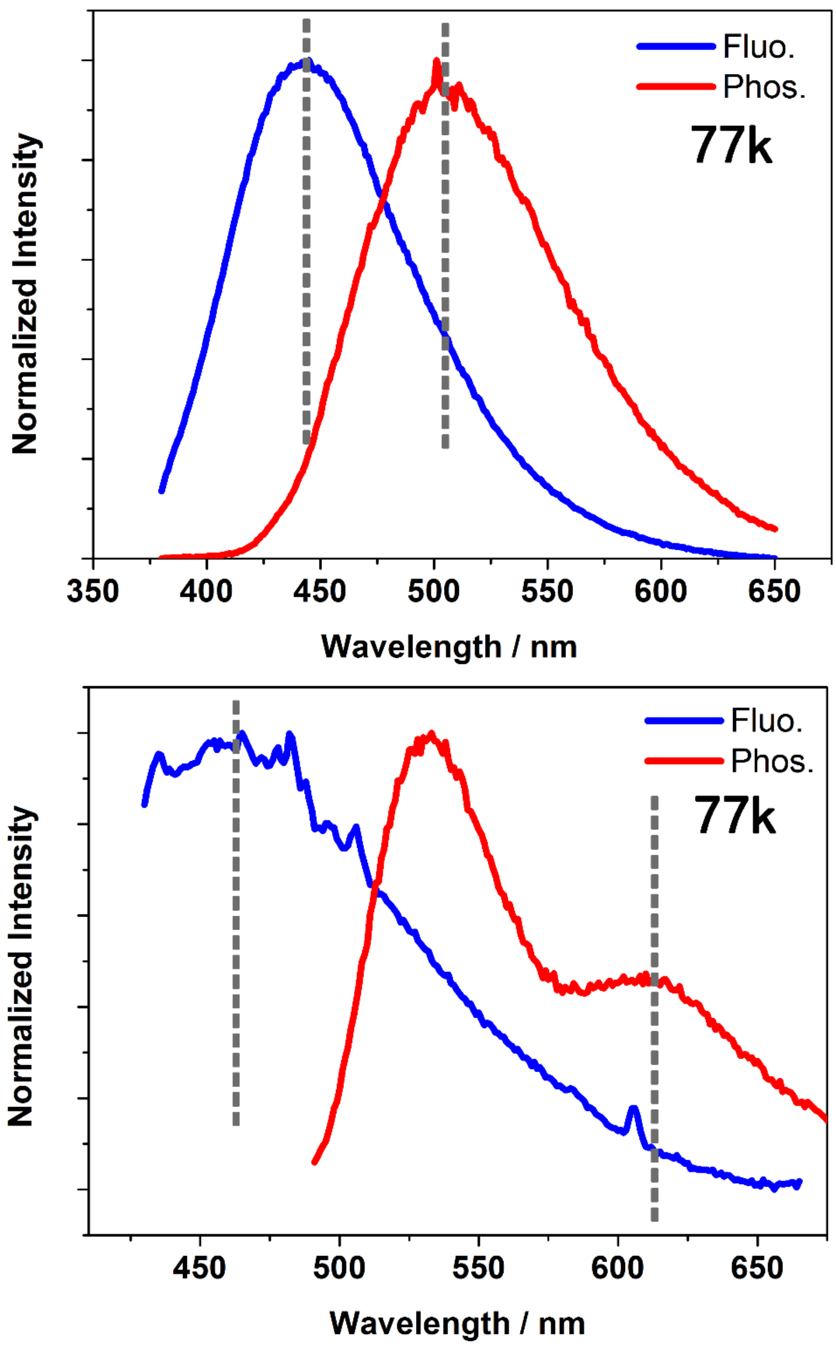


Figure S11. The fluorescence spectra (blue line) and phosphorescence spectra (red line) of mother solution (up) and CDs@Mn-LEV (down) excited under 360 nm at 77 K.

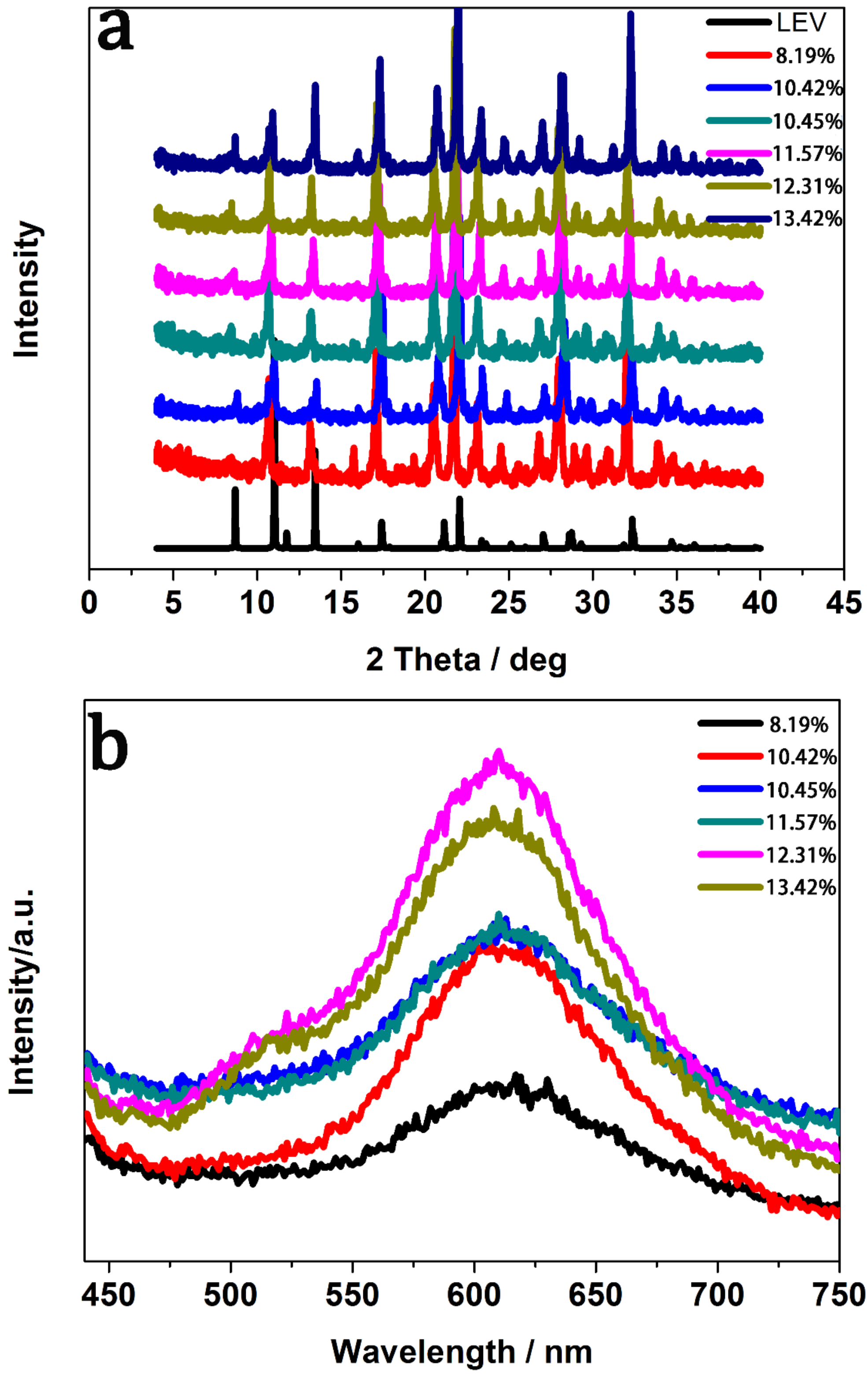

a
LEV
8.19%
10.42%
10.45%
11.57%
12.31%
13.42%
Intensity
0
5
10
15
20
25
30
35
40
45
2 Theta / deg
b
8.19%
10.42%
10.45%
11.57%
12.31%
13.42%
Intensity/a.u.
450
500
550
600
650
700
750
Wavelength / nm

Figure S12. a) Powder X-ray diffraction patterns of CDs@Mn-LEV with different amount of doping Mn atoms; b) Phosphorescent emission spectra of CDs@Mn-LEV with different amount of doping Mn atoms.

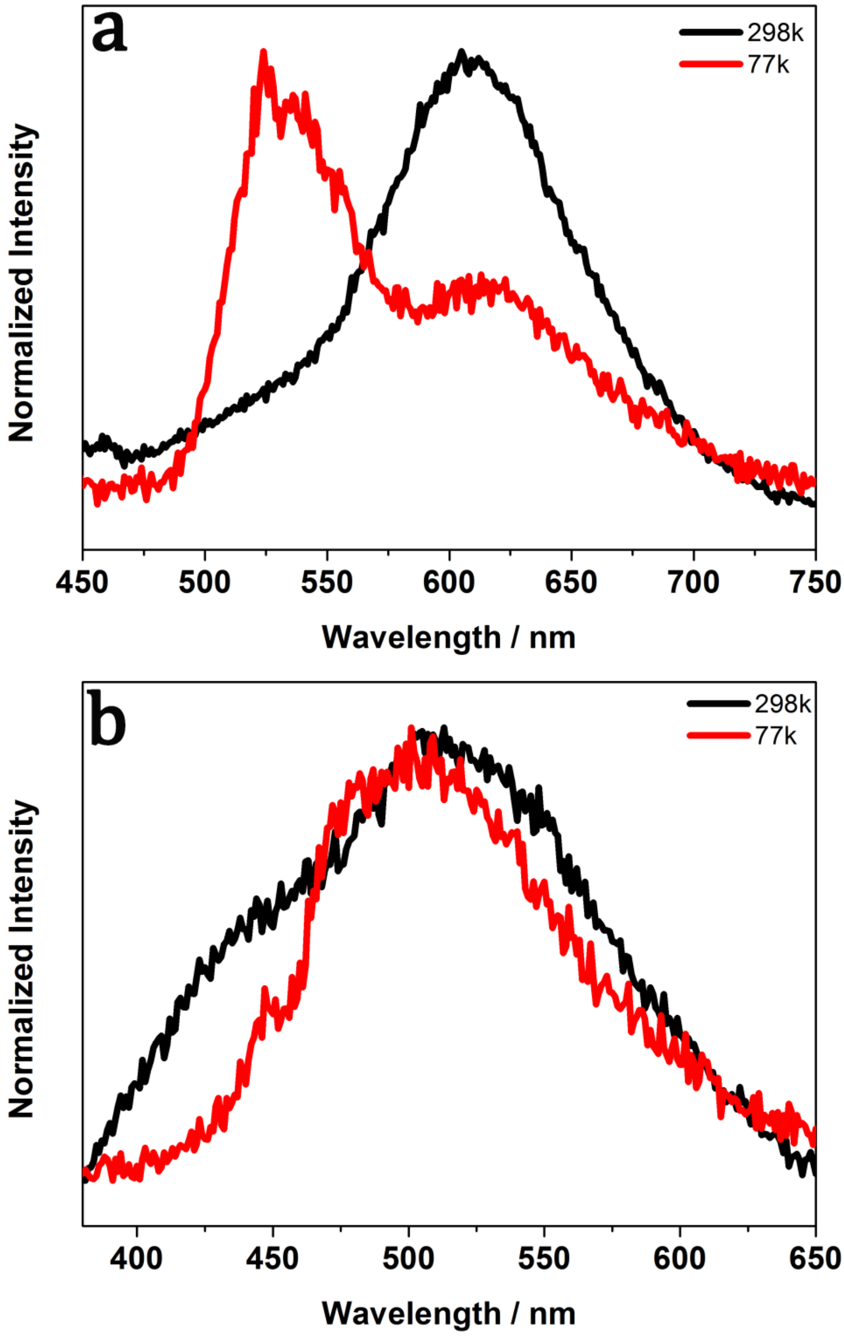
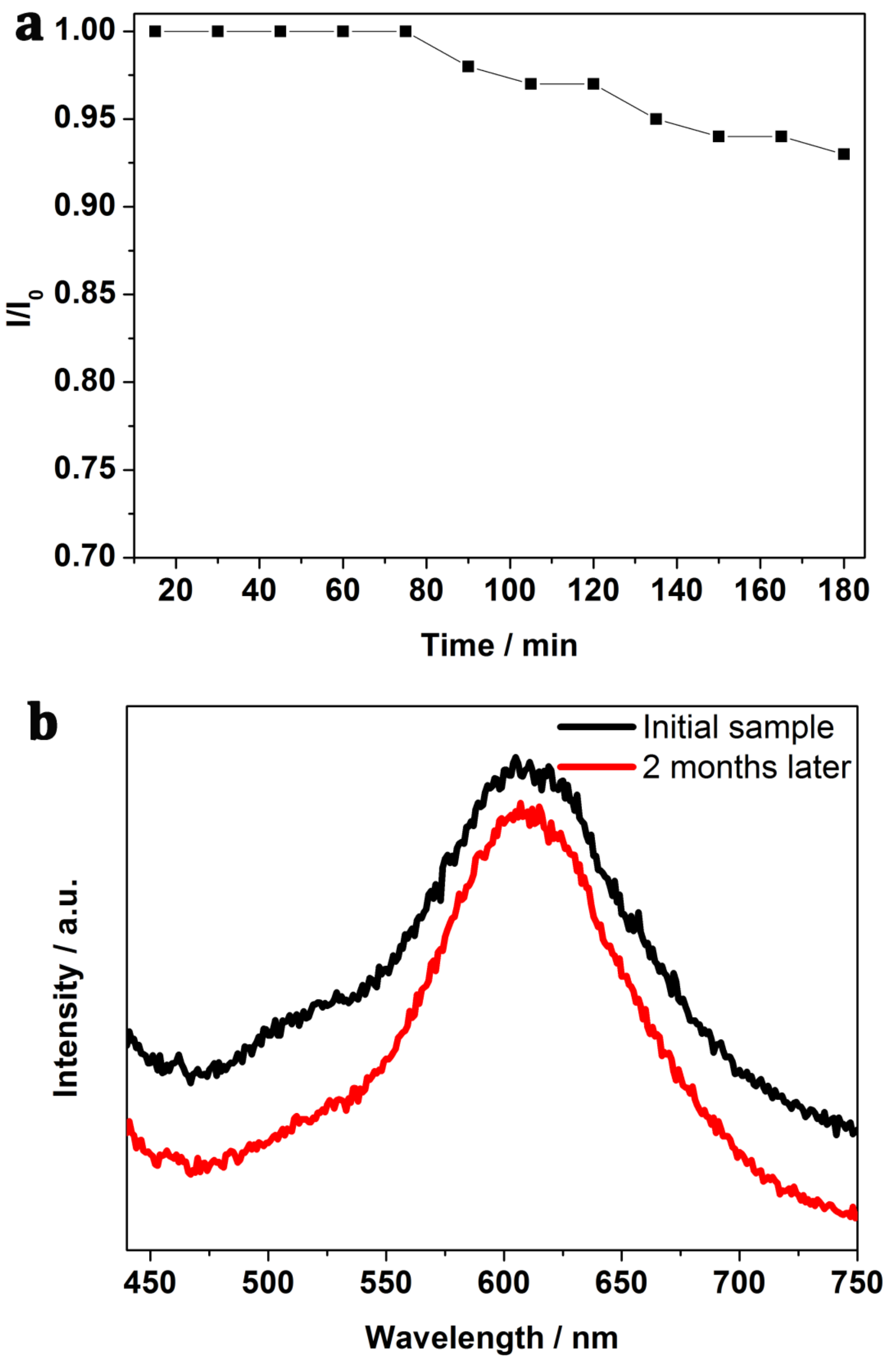


Figure S13. low temperature (77K) and room temperature (298K) phosphorescence spectra of a) CDs@Mn-LEV and b) CDs@Zn-CHA composites.



a
1.00
0.95
0.90
0.85
0.80
0.75
0.70
I/I0
20
40
60
80
100
120
140
160
180
Time / min
b
Initial sample
2 months later
Intensity / a.u.
450
500
550
600
650
700
750
Wavelength / nm

Figure S14. a) phosphorescence intensity ratios of CDs@Mn-LEV under UV lamp from 15 min to 180 min; b) phosphorescence emissions of CDs@Mn-LEV at the beginning and after 2 months.

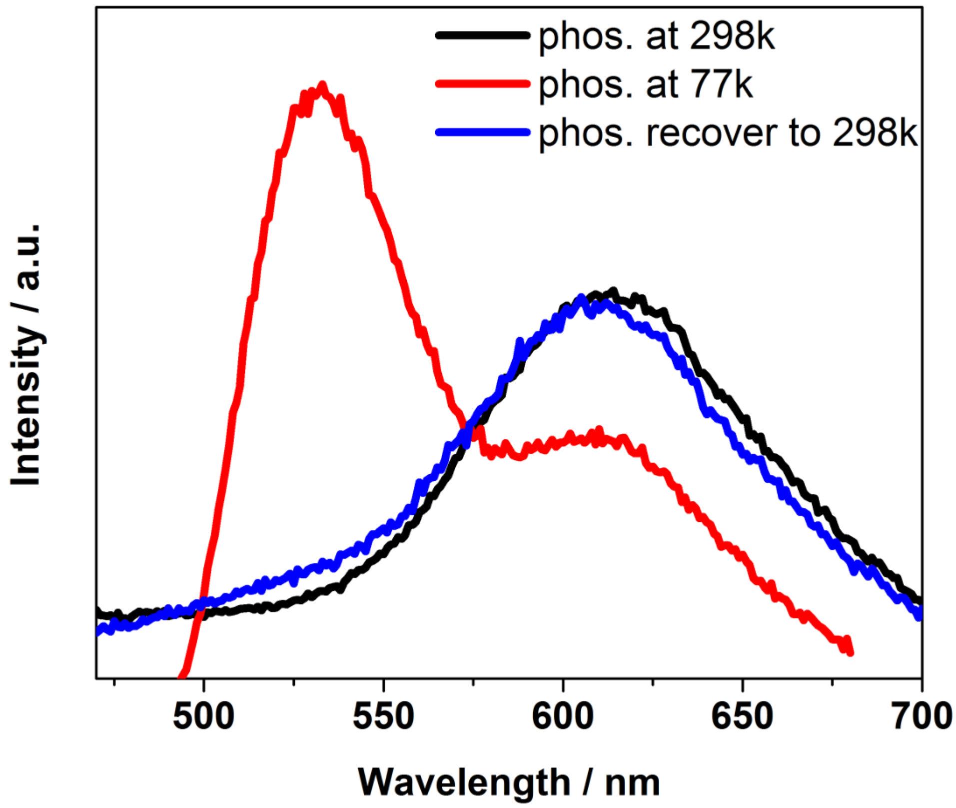


Figure S15. Recyclable thermal-responsive phosphorescence emission of CDs@Mn-LEV from green to red upon heating up from 77K to room temperature.

Table S1. Fitting parameters of time-resolved phosphorescence decay traces of CDs@Mn-LEV (λ_{ex}=420 nm, λ_{em}=620 nm) and CDs@Zn-CHA (λ_{ex}=300 nm, λ_{em}=500 nm).

	CDs@Mn-LEV	**CDs@Zn-CHA**
t_1/ms	0.239	1.899
$A_1/[A_1+A_2]$	37.44%	20.22%
t_2/ms	2.758	27.50
$A_2/[A_1+A_2]$	62.56%	79.78%
t_{ave}	1.814	22.32

Table S2. Fitting parameters of time-resolved phosphorescence decay traces of CDs@Mn-LEV, CDs@Zn-CHA and the mother solution of CDs@Mn-LEV under 77K (λ_{ex}=300 nm, λ_{em}=500 nm).

	Mother solution	**CDs@Mn-LEV**	**CDs@Zn-CHA**
t_1/ms	2.034	0.477	2.15
A_1/[A_1+A_2]	13.25%	29.07%	4.28%
t_2/ms	70.16	5.975	356.8
A_2/[A_1+A_2]	86.75%	70.93%	95.72%
t_{ave}/ms	61.13	4.37	341.6

Table S3. Fitting parameters of time-resolved phosphorescence decay traces of CDs@Mn-LEV with different amount of doping Mn atoms (λ_{ex}=420 nm, λ_{em}=620 nm).

$M_{(Mn(AC)2)}$[a]	M_{ratio}[b]	T_1/ms	A_1/A_1+A_2	T_2/ms	A_2/A_1+A_2	T_{Ave}/ms
0.35g	8.19	0.216	47.35%	2.242	52.65%	1.283
0.40g	10.42	0.224	42.67%	2.398	57.33%	1.470
0.45g	10.45	0.234	41.62%	2.397	58.38%	1.497
0.55g	11.57	0.222	44.37%	2.383	55.63%	1.424
0.60g	12.31	0.254	36.77%	2.752	63.23%	1.833
0.65g	13.42	0.247	34.55%	2.834	65.45%	1.940

[a]Mass of different amount of Mn in initial reaction gel.

[b]Mass ratio of different amount of Mn in CDs@Mn-LEV composites based on the ICP analysis..