Supporting Information

Room Temperature Phosphorescence of Carbon Dots Activated by Layered Double Hydroxides for the Application in Information Encryption

Ruixing Wang, Yunjun Zhu, Zhaojun Xia, Kaixiang Liang, Lingwei Kong, Jing Liu, Wenying Shi*, Chao Lu

[†]State Key Laboratory of Chemical Resource Engineering, Beijing University of Chemical Technology, 15 Beisanhuan East Road, P. Box 98, 100029, Beijing (P. R. China).

Corresponding Author
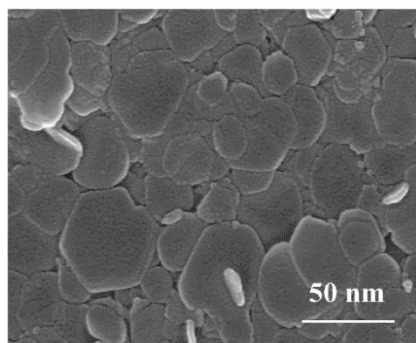
*E-mail: shiwy@mail.buct.edu.cn
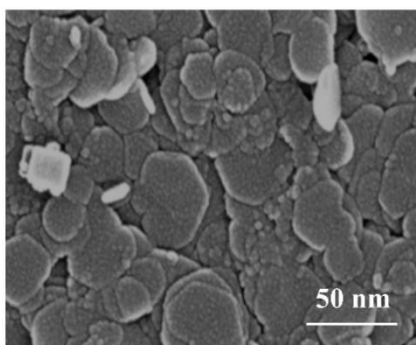
Figure S1. SEM images of LDHs-NO$_3$

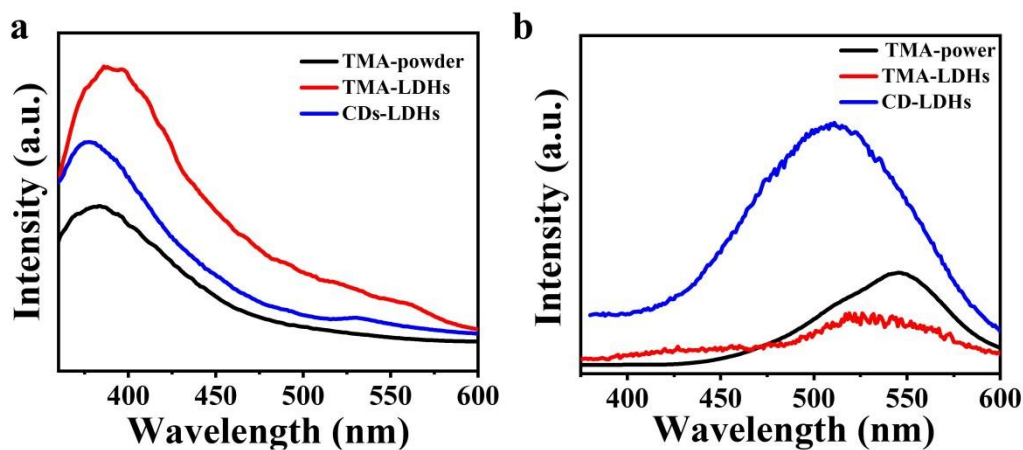**Figure S2.** SEM images of TMA-LDHs.

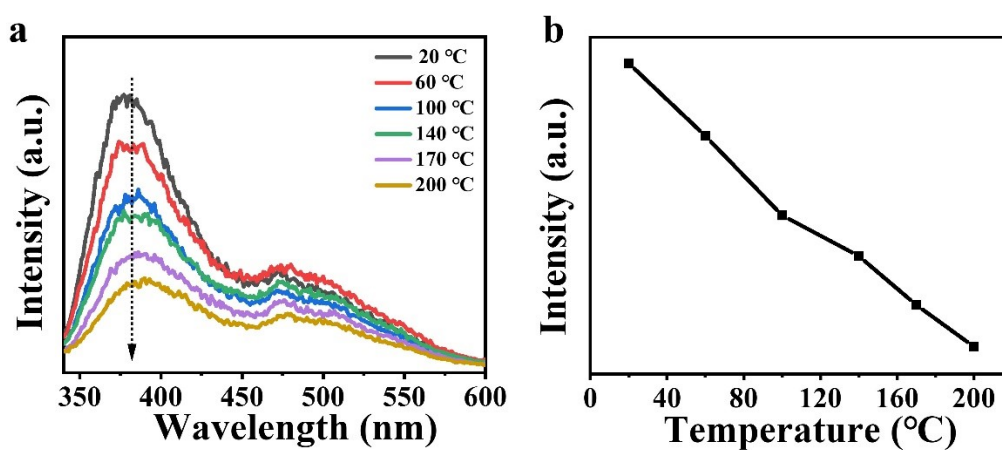**Figure S3.** (a) Fluorescence emission spectra. (b) Phosphorescence emission spectra.

Figure S4. (a) The fluorescence emission spectra of CDs-LDHs at different temperatures and (b) the relationship curve between fluorescence intensity and temperature.
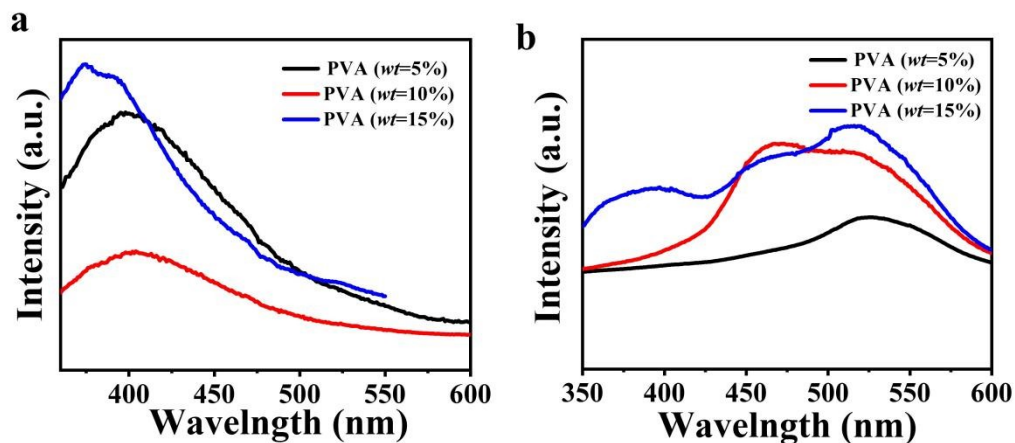
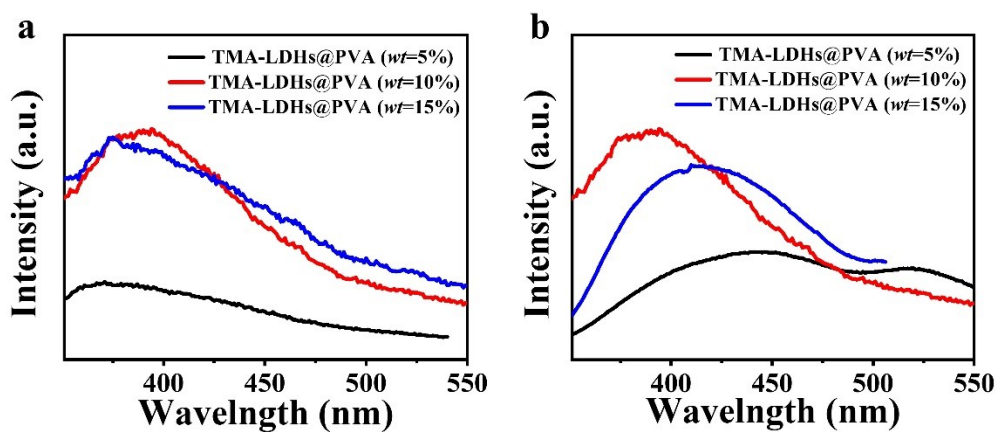**Figure S5.** (a) Fluorescence spectra of pure PVA films. (b) Phosphorescence spectra of pure PVA films.

Figure S6. (a) Fluorescence spectra of TMA-LDHs@PVA composites. (b) Phosphorescence spectra of TMA-LDHs@PVA composites.
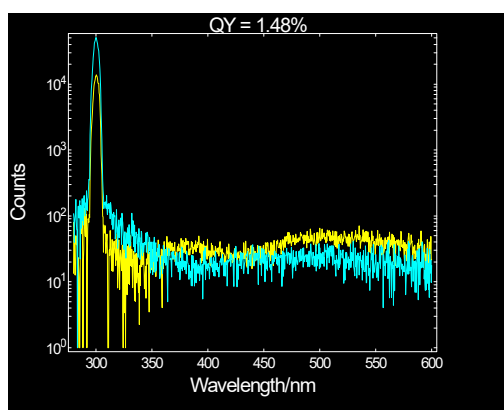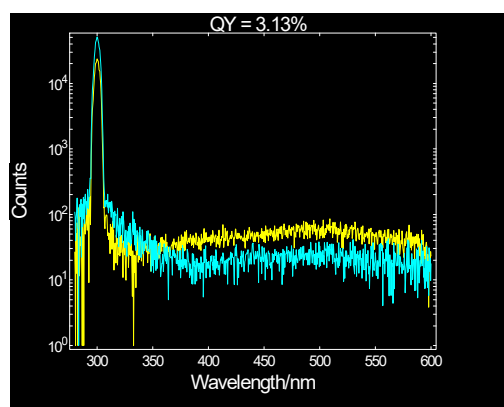
Figure S7. PL quantum yield of CDs-LDHs.

Figure S8. PL quantum yield of CDs-LDHs@PVA.

Quantum yield calculation of phosphorescence: The phosphorescence quantum yield is generally calculated by reference method [1]. That is, under the same excitation conditions, to measure the integrated phosphorescence intensity of the tested phosphorescence sample and the reference phosphorescence standard (the area included by the corrected fluorescence spectrum), and the absorbance of the incident light (UV-Vis) with the same excitation wavelength, and then substitute the measured value into the following quantum yield calculation formula:

$$Yu = \frac{Ys \times Fu}{Fs} \times \frac{As}{Au}$$

Ys refers to the phosphorescence quantum yield of the matter to be tested and the

reference standard matter; Fu and Fs refer to the integrated phosphorescence intensity of the substance to be tested and the reference material; Au and As refer to the incident absorbance ($A= \varepsilon bc$) of the incoming matter to be measured and the reference standard matter. When using this formula, it is generally required that the absorbance As and Au should be lower than 0.05. It is better to select phosphorescence materials with similar excitation wavelength values for reference standard samples.
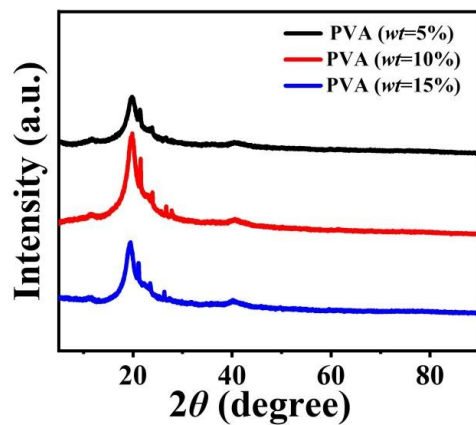
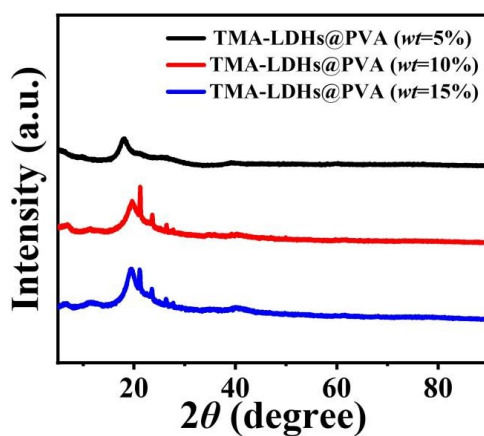**Figure S9.** XRD patterns of PVA films with different mass fractions.

Figure S10. XRD patterns of composites prepared from TMA-LDHs and PVA solutions with different mass fractions.
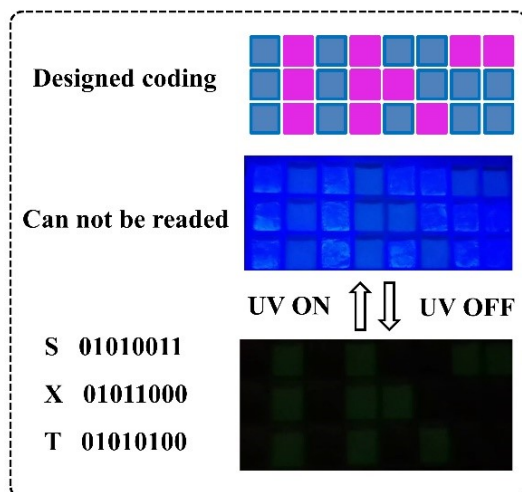
Figure S11. Schematic diagram of data encoding/reading strategy based on the CDs-LDHs.

Based on the CDs-LDHs, we make a microarray data storage schema based on the binary encoding of standard 8-bit ASCII characters. As shown in Figure S11, blue and purple marker spots represent "0" and "1", respectively. In the experiment, all spots show blue fluorescent signal under 365nm UV excitation, and then according to the ASCII binary code, it can be translated into invalid information. While after UV excitation is turned off, the dots labeled with CDs-LDHs are bright green, and the dots labeled with phosphor 1-naphthoic acid have no phosphorescent signal, which can be easily read and converted according to ASCII binary code. Translated to "01010011", "01011000", "01010100", corresponding to capital letters "S", "X" and "T".

Table S1. The fluorescence decay of CDs-LDHs and CDs-LDHs@PVA

Sample	τ_1 (ns)	A_1 (%)	τ_2 (ns)	A_2 (%)	χ^2	τ_{ave} (ns)
CDs-LDHs	8.66	69.31	3.07	30.69	1.14	1.54
CDs-LDHs@PVA	1.07	73.62	4.23	26.38	1.14	1.91

Table S2. The Phosphorescence decay of CDs-LDHs and CDs-LDHs@PVA

Sample	τ_1 (ms)	A_1 (%)	τ_2 (ms)	A_2 (%)	χ^2	τ_{ave} (ms)
CDs-LDHs	8.61	14.19	197.8	85.81	1.61	170.95
CDs-LDHs@PVA	58.44	7.49	441.2	92.51	2.01	412.53

Table S3. Fluorescence quantum yield of CDs-LDHs and CDs-LDHs@PVA

Sample	QY
CDs-LDHs	0.37%
CDs-LDHs@PVA	0.57%

Table S4. Phosphorescence quantum yield of CDs-LDHs and CDs-LDHs@PVA

Sample	QY
CDs-LDHs	1.48%
CDs-LDHs@PVA	3.13%

Supplementary References:

1 K. Hanaoka, Y. Muramatsu, Y. Urano, T. Terai, T. Nagano, *Chem. Eur. J.*, 2010, **16**, 568–572.