

## Supporting Information

### **Time-dependent room temperature phosphorescence colors from sulfur-doped carbon dot-based composite for advanced information encryption and anti-counterfeiting**

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### Calculation of photoluminescence lifetimes :

For the time-resolved fluorescence/afterglow decay curves, the average lifetimes were calculated using the following equation:

$$\tau_{avg} = \frac{\sum a_i \tau_i^2}{\sum a_i \tau_i}$$

And the time-resolved luminescence decay curves were fitted with tri-exponential functions.

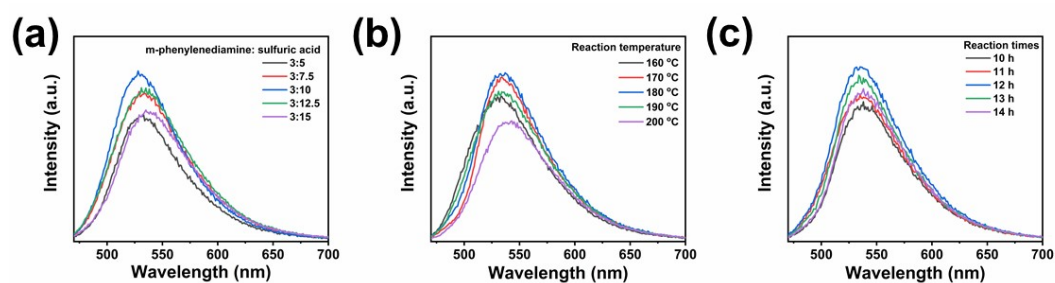


Figure S1 Photoluminescence spectra of SCDs with different (a) mass ratios of precursors (m-phenylenediamine: sulfuric acid), (b) reaction temperatures, and (c) reaction times.

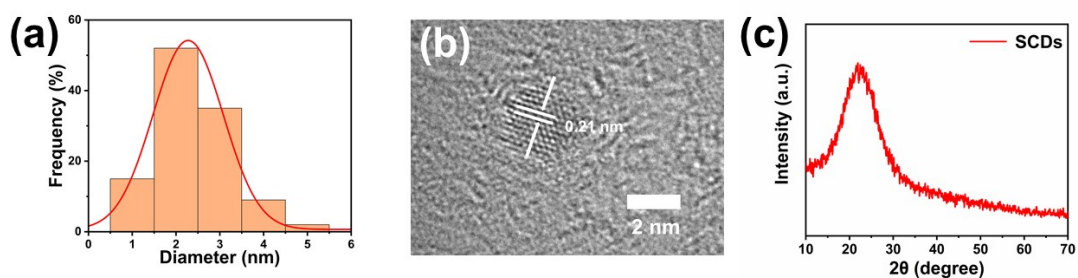


Figure S2 (a) Diameter histogram of SCDs. (b) HR-TEM image of SCDs. (c) XRD pattern of SCDs.

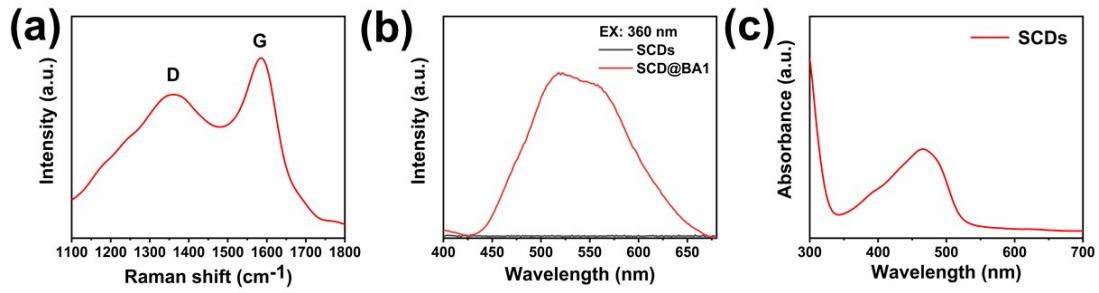


Figure S3 (a) Raman spectrum of SCDs. (b) Afterglow spectra of SCDs powders and SCD@BA1 composite powders. (c) Absorption spectra of SCDs aqueous solution.

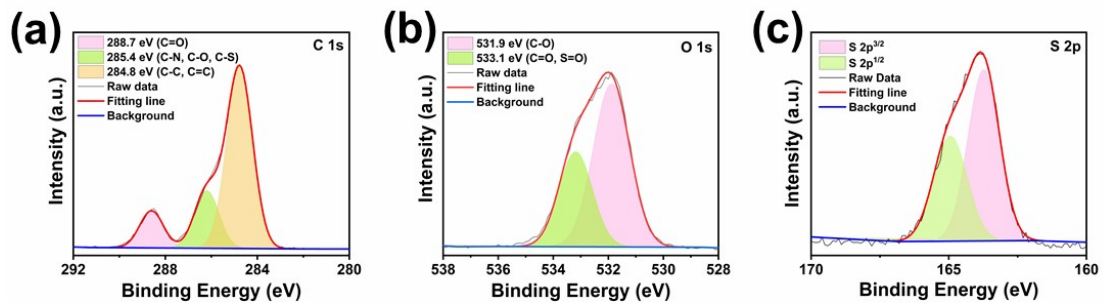


Figure S4 High-resolution XPS spectra of SCDs: (a) C 1s, (b) O 1s, and (c) S 2p.

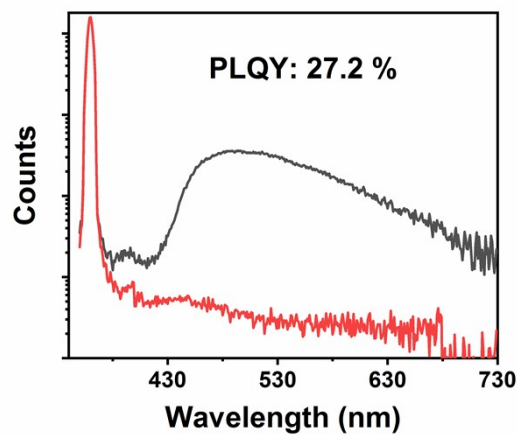


Figure S5 The PLQY of SCD@BA1 powders excited at 360 nm.

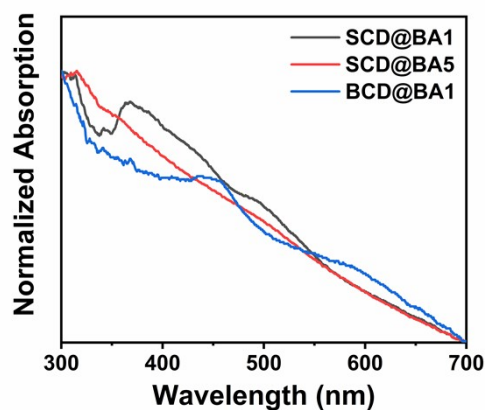


Figure S6 Absorption spectra of SCD@BA1, SCD@BA5, and BCD@BA1 composites.

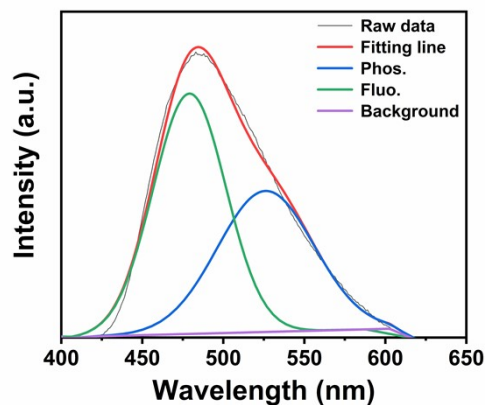


Figure S7 Photoluminescence spectra of SCD@BA1 composite excited at 360 nm which deconvoluted into fluorescence and phosphorescence.

### Calculation of the phosphorescence quantum yield (QY):

The photoluminescence of SCD@BA1 composite is measured about 27.2 % (380 nm-700 nm). The photoluminescence curve was deconvoluted into two peaks which belonging to fluorescence and phosphorescence. The proportion of phosphorescence is about 43.73 % in the total luminescence intensity. Thus the phosphorescence QY is about 11.89 %.

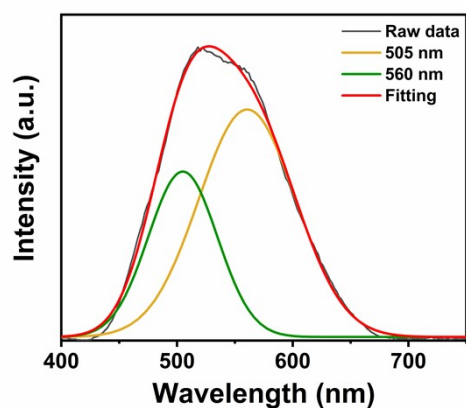


Figure S8 Afterglow spectra of SCD@BA1 composite excited at 360 nm (delayed by 0.5 ms).

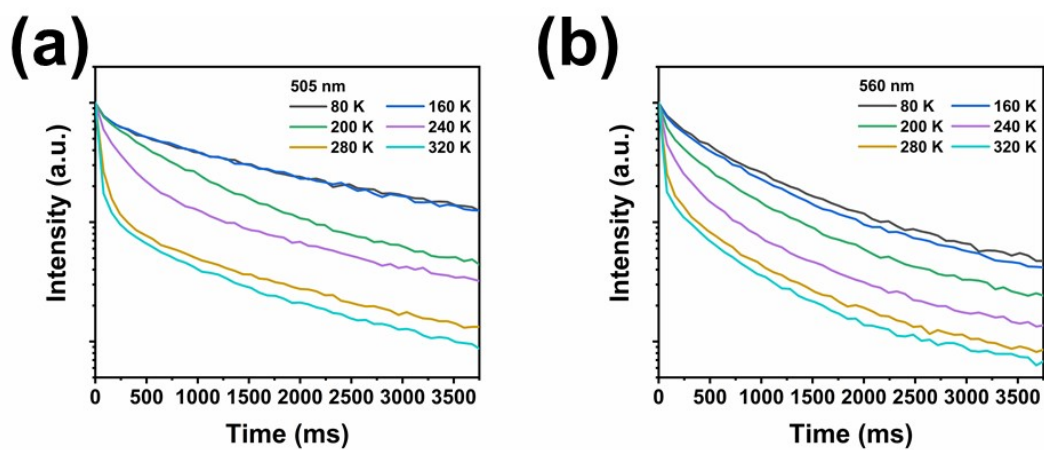


Figure S9 Temperature-dependent afterglow decay curves of SCD@BA1 composite at (a) 505 nm and (b) 560 nm. (excited at 360 nm)

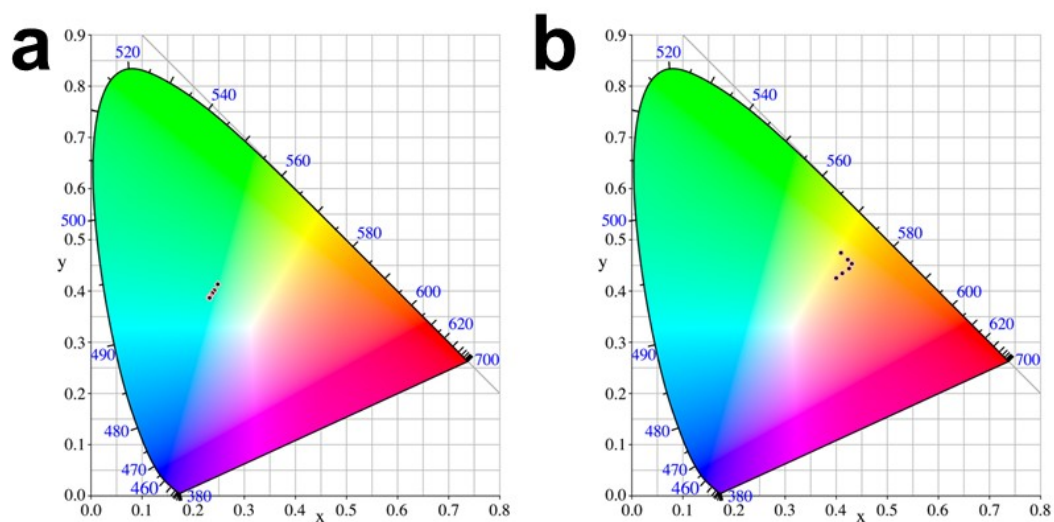


Figure S10 CIE coordinates of time-dependent afterglow colors of SCD@BA1 composite after excited at (a) 320 nm and (b) 390 nm.

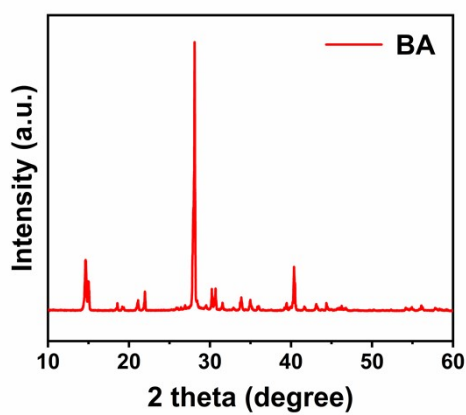


Figure S11 XRD patterns of BA.

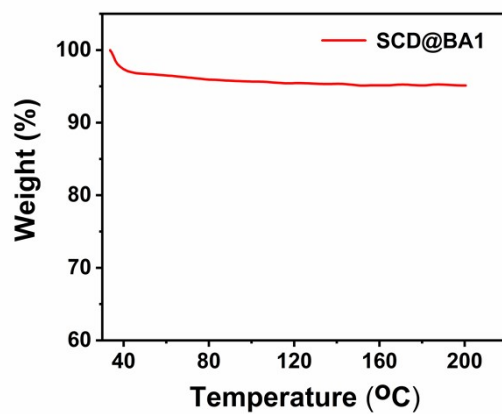


Figure S12 TGA curves of SCD@BA1 composite.

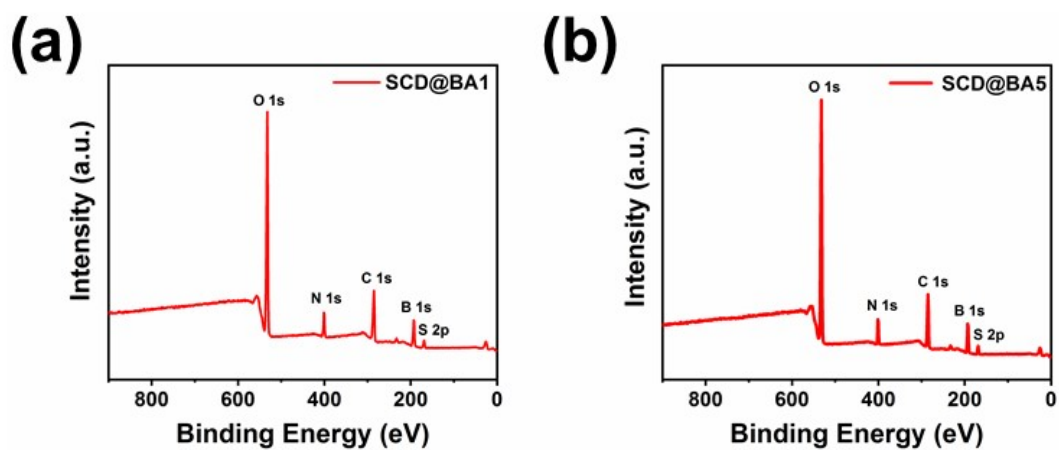


Figure S13 (a) Full XPS spectra of SCD@BA1. (b) Full XPS spectra of SCD@BA5.

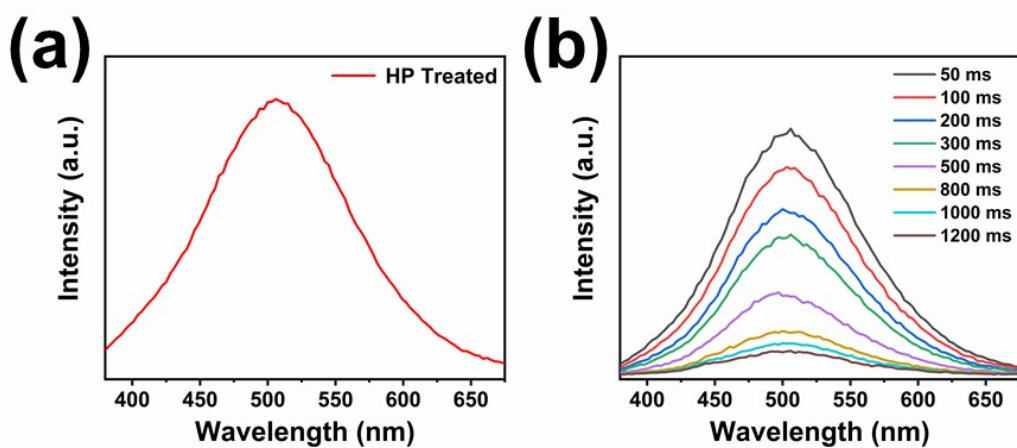


Figure S14 (a) Afterglow spectra of SCD@BA1 composite treated by hydrogen peroxide (HP). (b) Time-dependent afterglow spectra of SCD@BA1 composite treated by HP.