Electronic Supplementary Material

Lignin-derived dual-function red light carbon dots for hypochlorite detection and anti-counterfeiting

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1. EXPERIMENTAL SECTION

1.1. Reagents and Materials

Alkali lignin, o-phenylenediamine, phosphoric acid, sulfuric acid were purchased from Aladdin Ltd., Shanghai, P. R. China. ClO^- (0.05020 $mol \cdot L^{-1}$) was purchased from Tanmo Quality Inspection Technology Co., LTD. $NaNO_2$, $CuCl_2$, $NaClO_4$, $CoCl_2$, $NiCl_2$, $MgCl_2$, $PbCl_2$, $FeCl_2$, $MnCl_2$, $NaNO_3$ $AlCl_3$, KCl, KI, $HgCl_2$, NaCl, $FeCl_3$ were purchased from Kermel Chemical Reagent Ltd., Tianjin, P. R. China. All reagents were of analytical grade and used as received.

1.2. Instrumentation

Transmission electron microscopy (TEM) images were acquired with a JEM-2100 microscope (JEOL) by using copper grids. X-ray photoelectron spectroscopy (XPS) analysis were recorded with a Thermo Fisher K-Alpha spectrometer (Thermo Fisher, USA). Fourier transform infrared (FT-IR) spectra of the SPN-CDs was collected using a Nicolet FT-IR 360 spectrometer within the range of 400 to 4000 cm^{-1}. The UV-vis absorption spectra were analyzed with a Shimadzu UV-2550 spectrophotometer. The photoluminescence spectra of the resulting solutions were measured on a Shimadzu RF-6000 PC fluorescence spectrometer equipped with a xenon lamp at room temperature. During the whole experiment, a quartz cuvette with an optical path of 1 cm was used and the slit width of the fluorescence emission and excitation spectra was set to 5 nm under ambient conditions. The fluorescent lifetime measurements were recorded on FLS980 fluorescence spectrometer. Also, constituents of SPN-CDs were characterized by proton nuclear magnetic resonance (^{1}H NMR).

1.3. Quantum yield measurements

The quantum yield measurement was performed by the FLS980 fluorescence spectrometer. Fluorescence spectra were collected in the range of 547-577 and 582-800 nm, respectively. Meanwhile, the same fluorescence spectra were also recorded for pure water under the same conditions. Each experiment was performed 3 times in parallel, and the average value of quantum yield was taken. A quantum yield value of 4.5% was obtained.

2. Spectroscopic properties of SPN-CDs

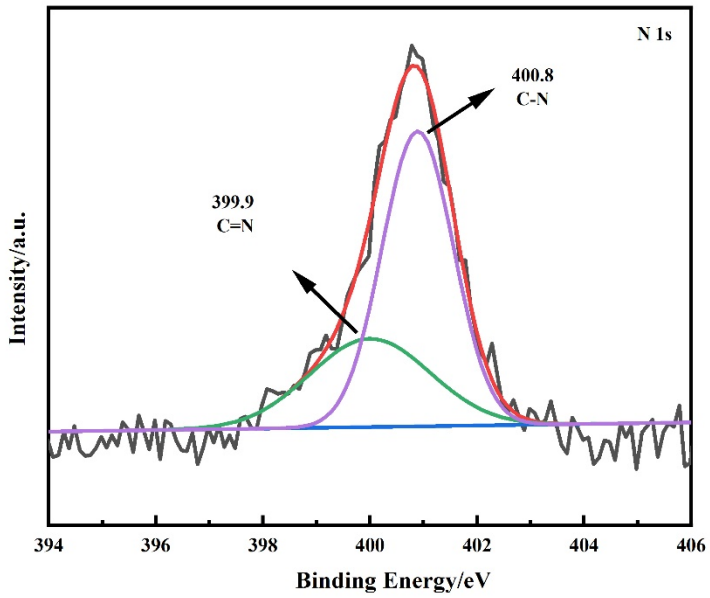

Fig. S1 High resolution XPS spectrum of N 1s region of SPN-CDs.

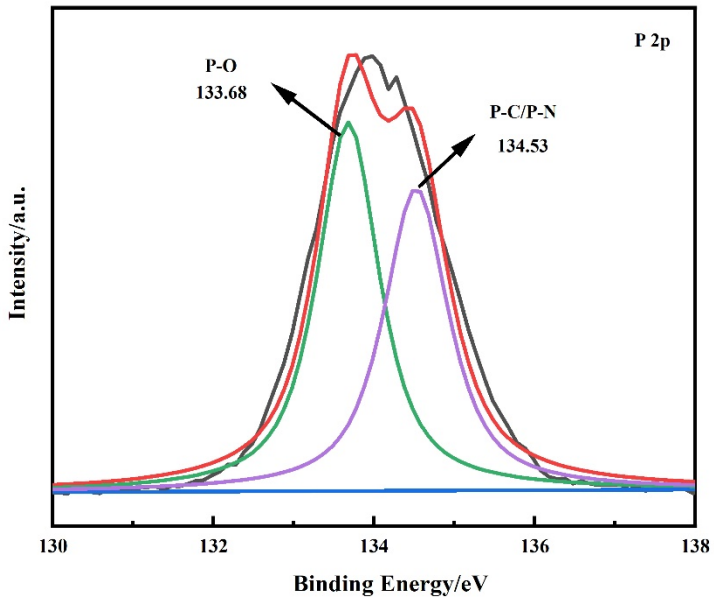

Fig. S2 High resolution XPS spectrum of P 2p region of SPN-CDs.

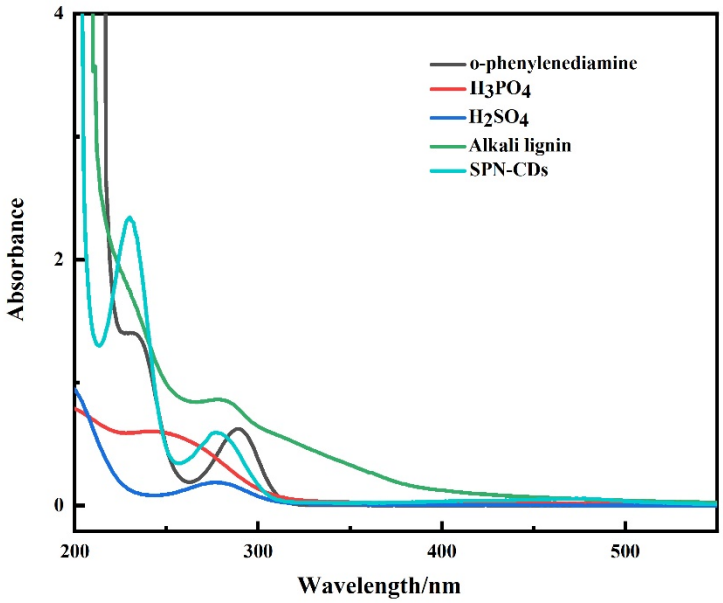

Fig. S3 Absorption spectra of o-phenylenediamine, phosphoric acid, sulfuric acid, alkali lignin and SPN-CDs.

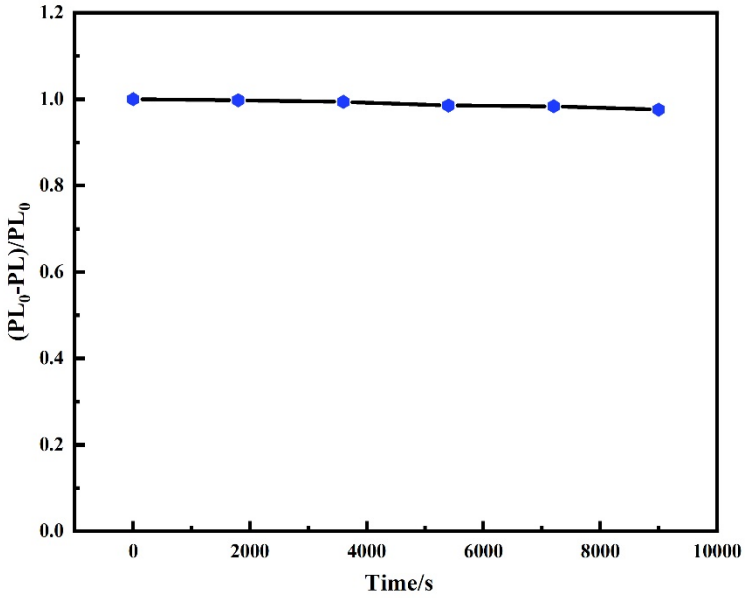

Fig. S4 Fluorescence properties of SPN-CDs at continuous UV irradiation.

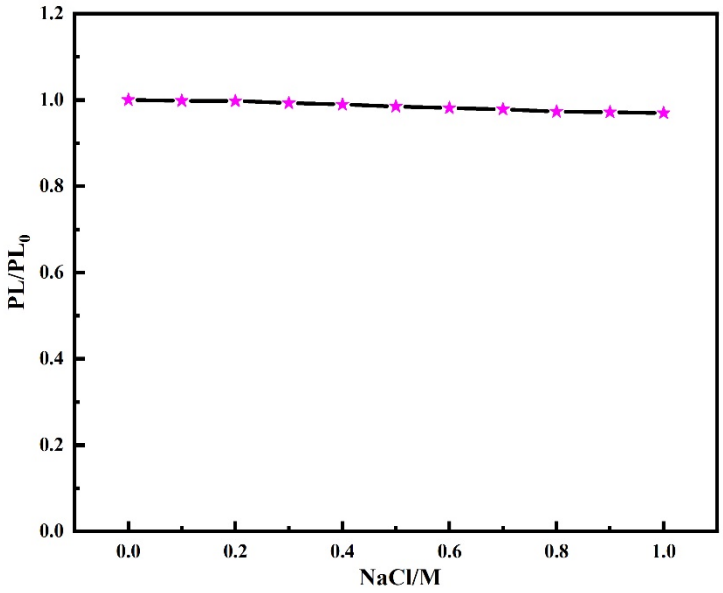

Fig. S5 Fluorescence properties of SPN-CDs at different concentration of NaCl.

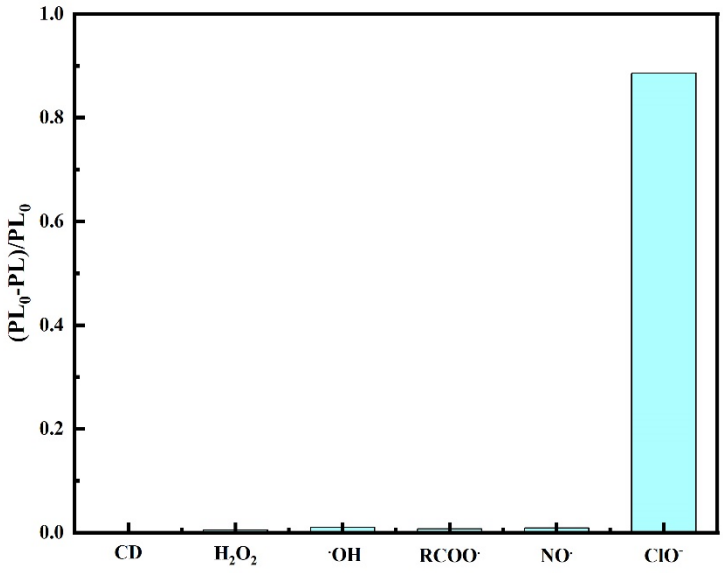

Fig. S6 Photoluminescence intensities change of the SPN-CDs probe to other radical species (0.05 mM). λex = 562 nm.

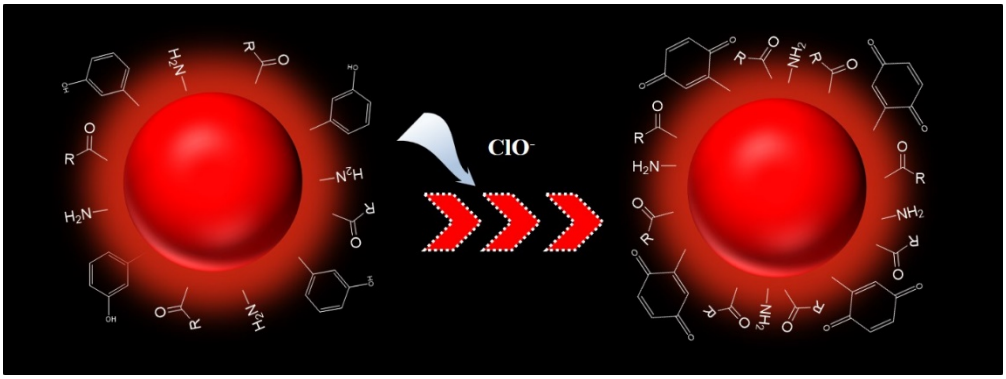

Fig. S7 The scheme of reaction mechanism.

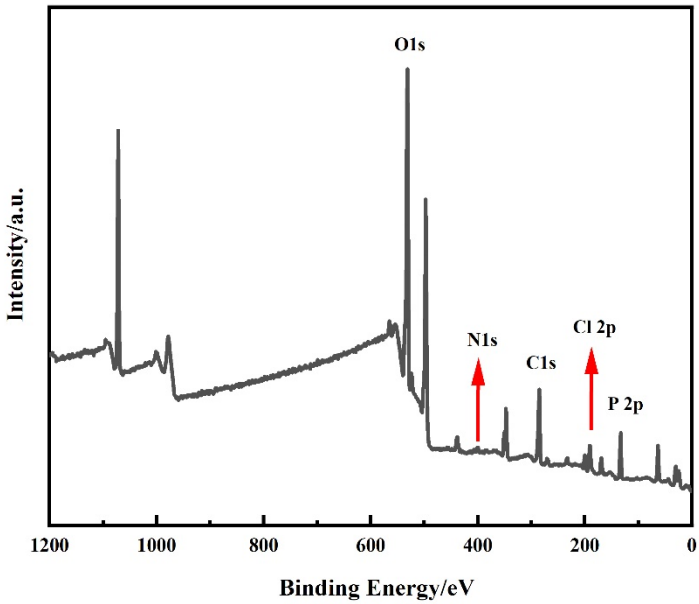

Fig. S8 XPS spectrum of SPN-CDs + ClO^-.

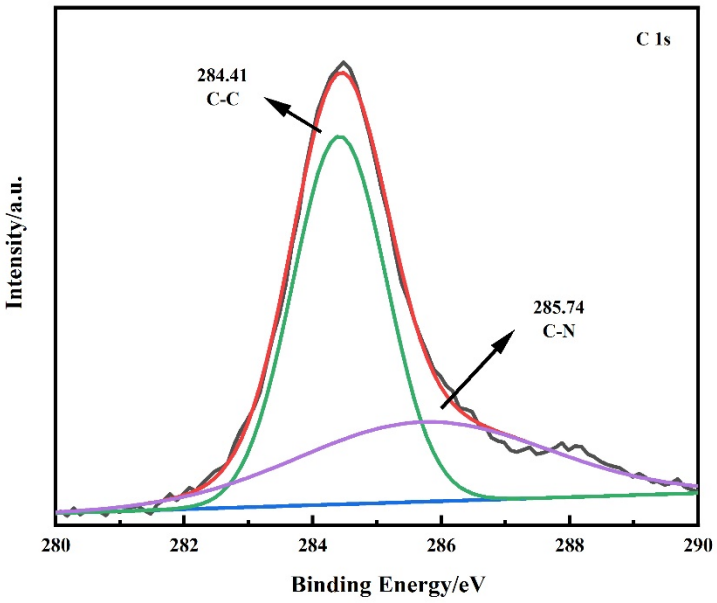

Fig. S9 High resolution XPS spectrum of C 1s region of SPN-CDs + ClO^-.

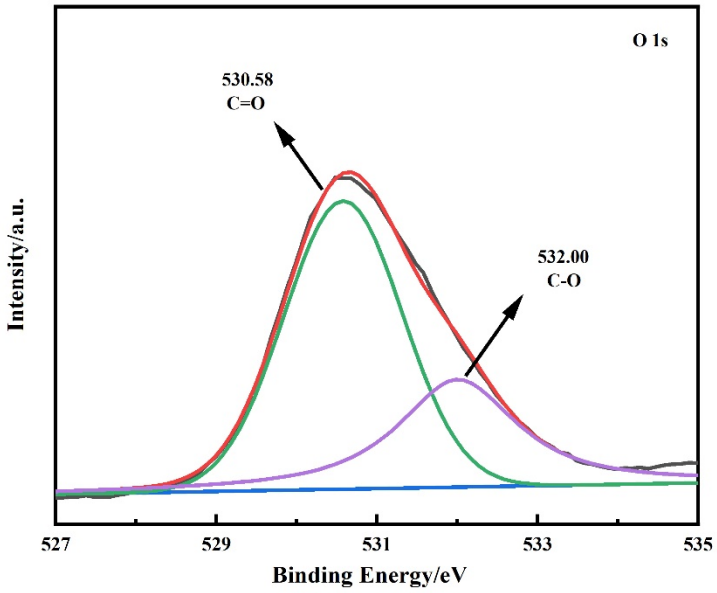

Fig. S10 High resolution XPS spectrum of O 1s region of SPN-CDs + ClO^-.

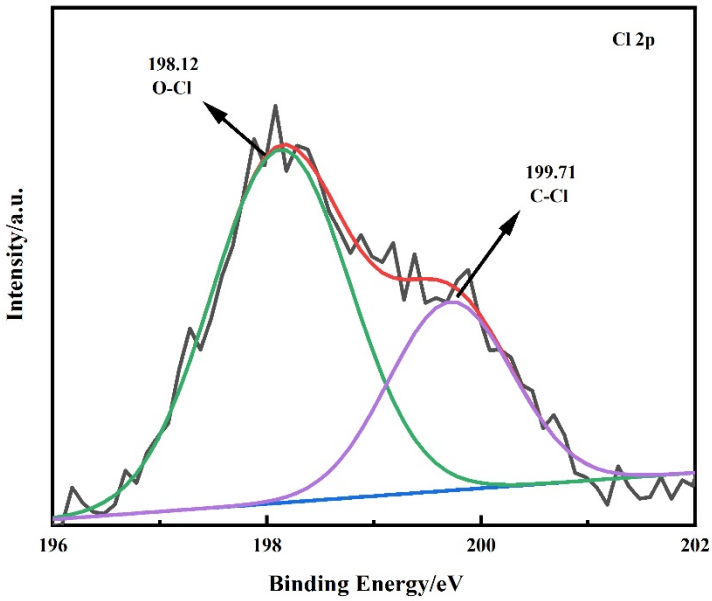

Fig. S11 High resolution XPS spectrum of Cl 2p region of SPN-CDs + ClO^-.

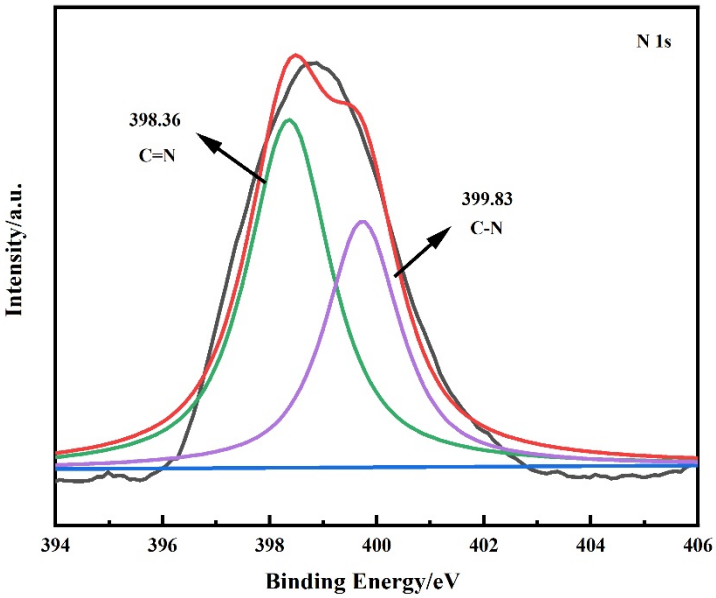

Fig. S12 High resolution XPS spectrum of N 1s region of SPN-CDs + ClO^-.

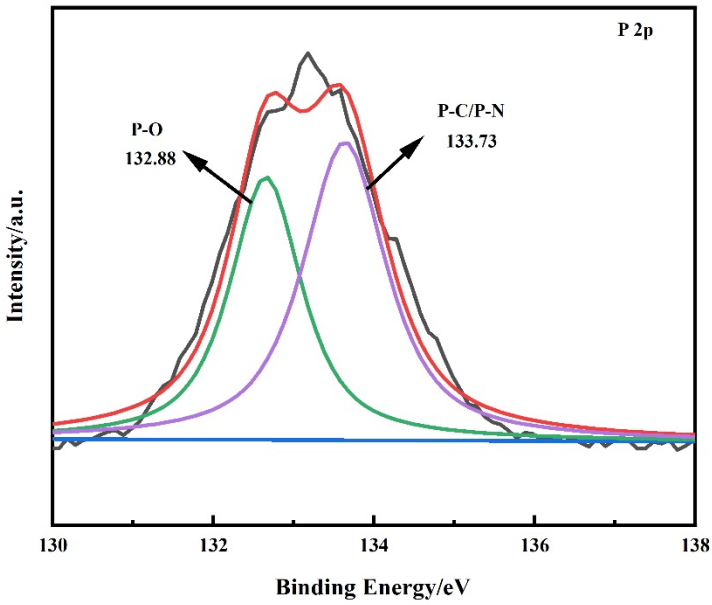

Fig. S13 High resolution XPS spectrum of P 2p region of SPN-CDs + ClO^-.

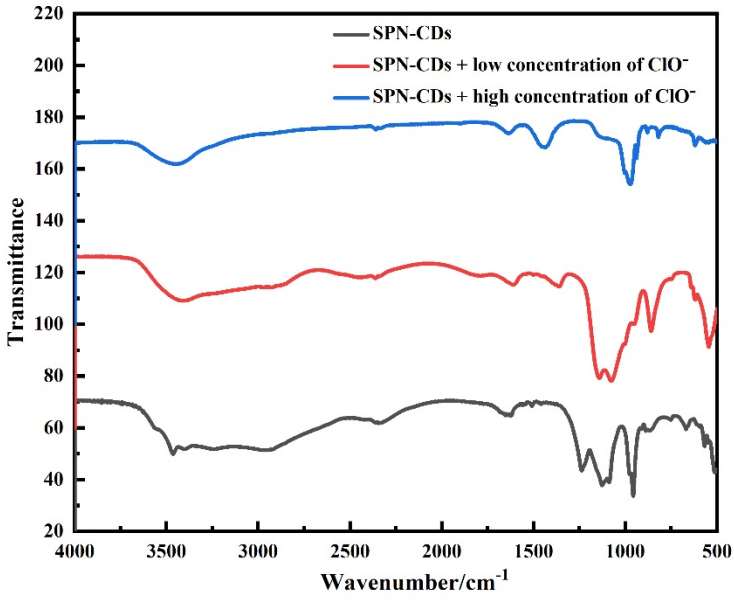

Fig. S14 Fluorescence decays spectrum of the SPN-CDs in the presence and absence of ClO^-.

3. Detection limit of SPN-CDs

The detection limit was calculated according to the formula LOD =3σ/S, where σ and S are corresponding to the standard deviation of the 11 blank samples and the slope of the fitting line, respectively. The results calculated that σ = 0.00116.

4. Table S1 Sensing performance comparison with other reported ClO^- detection probes

Sensor System	Linear Range / mM	LOD / μM	Reference
N-doped carbon dots	0.01-1	0.82	[1]
N, S-doped carbon dots	0.067-0.267	13.3	[2]
3-aminophenylboronic acid, alizarin red S-doped carbon dots	0-0.2	4.47	[3]
Tricyanoethylene-derived colorimetric probe	0-0.12	4	[4]
N-doped carbon dots	0.001-0.1	0.5	[5]
N-doped carbon dots	0-0.15	3.4	[6]
Green-emitting carbon quantum dots	0.01-0.15	1.82	[7]
S, P, N-doped carbon dots	0-0.5	0.249	This work

5. References

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