Supporting information for

Halogen Aions (F⁻, Cl⁻, Br⁻) Modulated Localized Microstructure of g-C$_3$N$_4$ to Facilitate Charge Separation and Transport and Enhance Photocatalytic Activities

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Table S1. structural information summary of prepared samples.

Samples	Surface Area (m^2g^{-1})	Pore diameter (nm)	Pore volume (cm^3/g)
CN	44.86	30.47	0.072
CN-F	45.82	32.63	0.077
CN-Cl	46.34	25.67	0.073
CN-Br	45.14	30.16	0.061

Table S2. The relative amounts of various elements in CN, CN-F, CN-Cl and CN-Br based on the XPS (Unit: at. %).

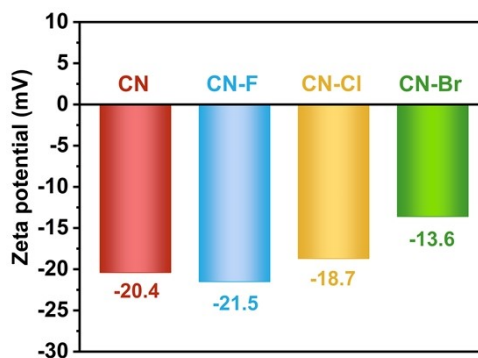|	C	N	X(F/Cl/Br)	C/N
CN	44.86	55.14	0	0.814
CN-F	45.82	53.78	0.40	0.852
CN-Cl	46.34	53.62	0.04	0.864
CN-Br	45.14	54.79	0.07	0.824

Figure S1. The zeta potential of as prepared CN, CN-F, CN-Cl and CN-Br samples.
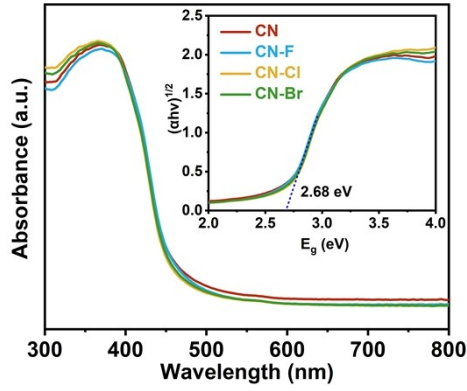
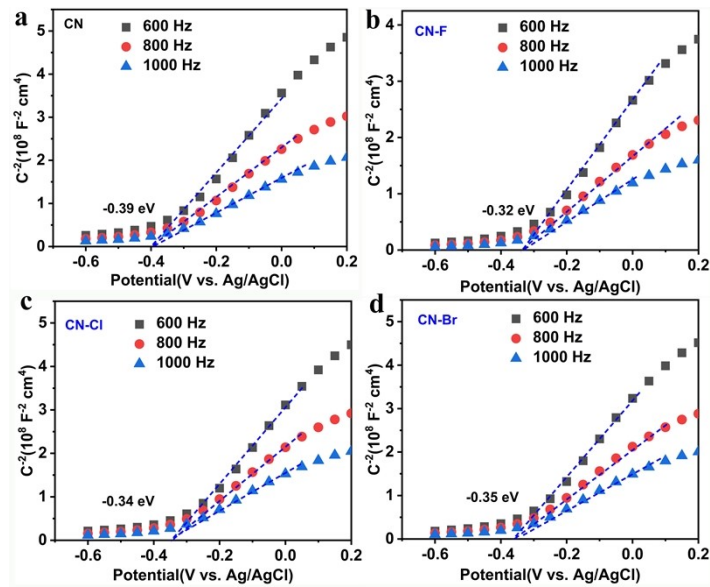**Figure S2.** The UV-Vis DRS results of CN, CN-F, CN-Cl and CN-Br. (inset is the corresponding Tauc plots).

Figure S3. Mott-Schottky plots of (a) CN, (b) CN-F, (c) CN-Cl and (d)CN-Br measured at frequencies of 600, 800 and 1000 Hz.
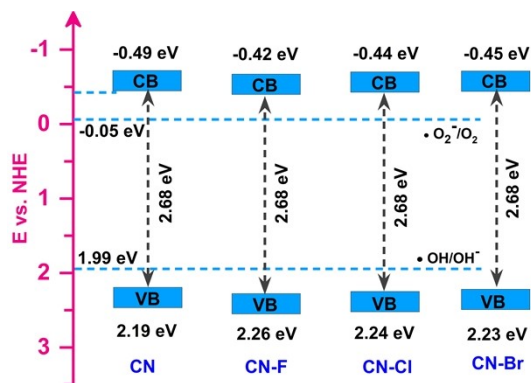
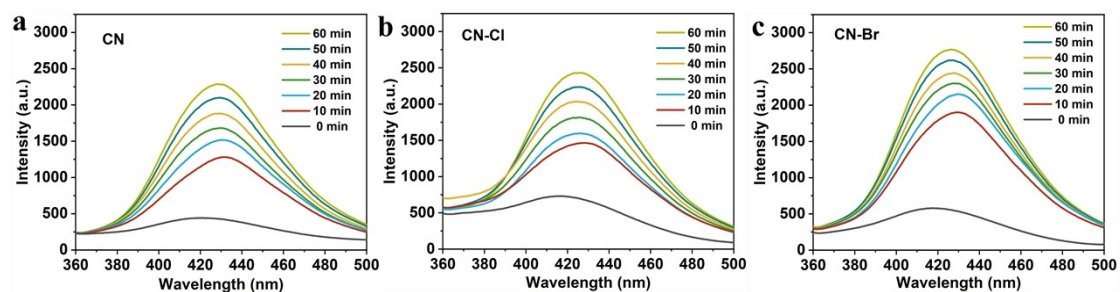**Figure S4.** As obtained band alignments over CN, CN-F, CN-Cl and CN-Br.

Figure S5. Time dependencies of the trapping PL spectra over (a) CN, (b) CN-Cl and (c)CN-Br catalyst in TA solution under visible light irradiation.
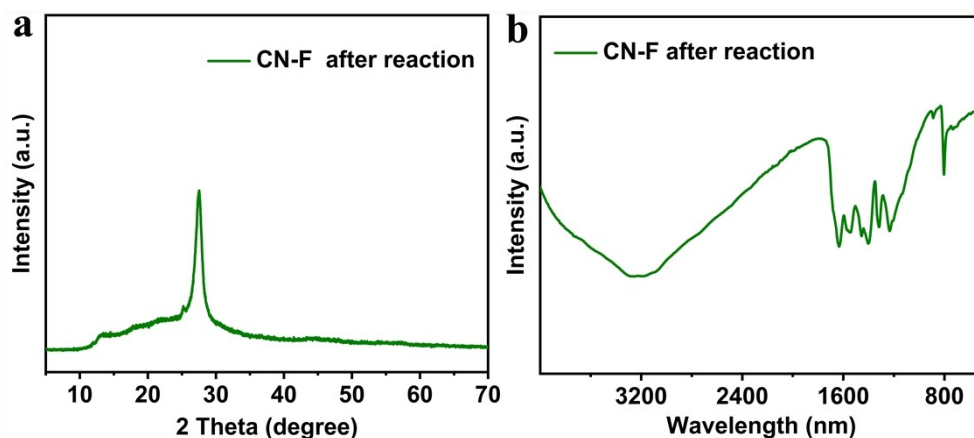

Figure S6. (a) XRD patterns and (b) FTIR spectra of used CN-F after catalytic reaction.
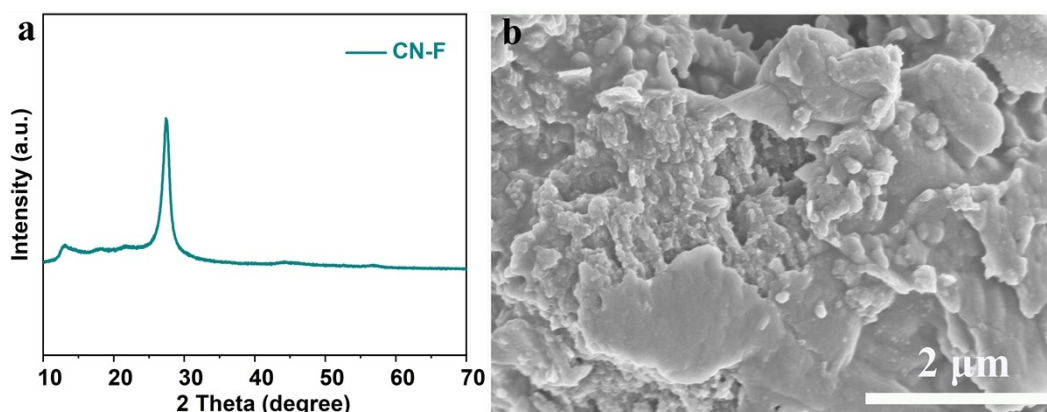
4

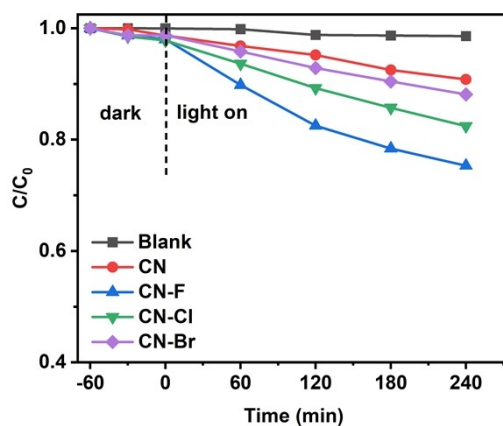**Figure S7.** (a) XRD patterns and (b) SEM image of CN-F after four consecutive photocatalytic degradation cycles.

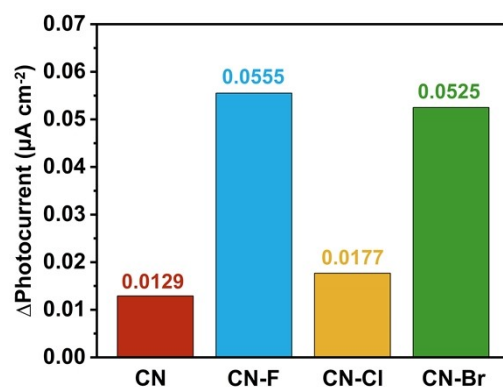**Figure S8.** Photocatalytic degradation performance of phenol solution (20 mg/L) over as prepared catalysts.

Figure S9. Photocurrent density difference (ΔI = the steady photocurrent (I_p) - the dark photocurrent (I_d)).

Table. S3. The fitted EIS results of CN and CN-X. R_s represents interface resistance and R_{ct} represents charge transfer resistance.

Sample	R_s/Ω	R_{ct}/Ω
CN	11.78	13363
CN-F	7.762	9220
CN-Cl	10.46	10363
CN-Br	8.068	10055

Table S4. The fitte TRPL results of as prepared CN and CN-X catalysts.

Catalyst	τ_1/ns	A_1	τ_2/ns	A_2	τ_a/ns
CN	1.834	1773.454	6.422	3.326	1.937
CN-F	1.979	1115.91	7.251	2.367	2.125
CN-Cl	1.940	1337.606	7.342	2.134	2.060
CN-Br	1.945	1261.753	7.133	2.513	2.080

Additional notes:

The average lifetime (τ_a) value is computed by the following formula:

$$\tau_a = \left(A_1\tau_1^2 + A_2\tau_{12}^2\right)/(A_1\tau_1 + A_2\tau_2)$$

A_1 and A_2 represent the amplitude of decay, τ_1, τ_2 is nonradiative recombination from charge carriers in defective sites and recombination from free excitons within the catalyst, respectively.